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ABSTRACT

Presented are architectural design issues associated with solar energy use, and procedures for design review committees to consider in examining residential solar installation in light of existing aesthetic goals for their communities. Recommended design review criteria include the type of solar system being used and the ways in which the system relates to the building's design, the building site, and the neighborhood. Also described are the appearance and functions of various types of solar energy systems. Technical appendices survey the design review process and present some proposed and adopted design criteria for solar buildings and installations. (Author/WB)

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Residential Solar Design Review

A Manual on Community Architectural Controls and Solar Energy Use

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Residential Solar Design Review

A Manual on Community Architectural Controls and Solar Energy Use

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The other two guidebooks in the series are:

Protecting Solar Access for Residential Development: A Guidebook for Planning Officials, by the APA.

Site Planning for Solar Access: A Guidebook for Residential Developers and Site Planners, by the APA.

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The Need for Solar Design Review

This guidebook examines some of the design issues associated with solar energy and suggests ways for design review committees to review solar installations and buildings in light of existing aesthetic goals in their communities. The guidebook does not dictate good taste nor does it recommend that a reviewer judge solar installations or buildings solely on the grounds of aesthetics. In fact, recent state legislation in both California and Colorado has made it clear that aesthetics ought not be the sole ground for rejecting solar installations and buildings. (This legislation is discussed in Appendix I.)

There are certain strategies, however, that design reviewers can use to overcome rising conflicts between local design objectives and solar energy use without compromising aesthetic goals. This guidebook examines those strategies and recommends design criteria that should be used to evaluate new solar installations and buildings. These criteria include the type of solar system being used and the ways in which the system relates to the building's design, the building site, and the neighborhood.

The guidebook is intended primarily for members of private architectural review committees of homeowner's associations, but it also may be useful to members of public design review boards, historic preservation commissions, and designers who present solar proposals to these boards and commissions. The reasons for this particular emphasis are twofold: (1) it is estimated that several thousand architectural review committees enforce private design restrictions. In contrast, there are perhaps several hundred public boards in existence; and (2) private review committees often have to rely more on their own judgment than do public committees and simply do not have the same access to architects or design professionals as do public committees.

As the number of solar energy installations increases, these design reviewers will be faced with a growing number of legal and regulatory issues. Four particular issues already merit special attention for design review boards:

Homeowners have sued design review boards which have prevented the installation of solar equipment or the use of solar building designs. Ways to accommodate solar design must be developed to forestall the inconvenience and expense of needless litigation.

Design goals and review procedures may have to be changed to meet new requirements. The lessons from California and Colorado laws can help review boards and design professionals avoid potential conflicts in their states by using criteria other than aesthetics to judge solar installations.

Public design review committees are one of many government agencies obliged to promote the general welfare. To that end, they should develop design criteria that reduce energy consumption and utility costs in a manner consistent with aesthetic objectives.

Design review committees and boards can help protect energy installations from shading problems since development next to the lot of a solar building under review is often examined as part of the design review process. Conflicts between the existing development and solar access needs of new installations can easily be identified and corrected during design review.

To help design reviewers resolve these issues, the guidebook has been organized in the following way. "What Solar Energy Systems Look Like" describes typical systems and explains why they look the way they do. "Design Strategies" examines design alternatives for highlighting, concealing, and integrating solar equipment into buildings; it offers options for relating the building to the site and into the existing neighborhood. "Design Review" presents suggestions for changing the design review process and standards to make them more sensitive to solar development. Technical appendices survey the design review process and present some proposed and adopted design criteria for solar buildings and installations.

What Solar Energy Systems Look Like

Active Systems
- The Collector
- The Location of Active Collectors
- Flush and Raised Installations
- Plumbing and Ductwork

Passive Systems
- The Collector
- Passive System Storage
- Panels, Shutters, and Curtains
- Shading Devices
- Passive Domestic Hot Water Systems
- Passive Cooling Systems

Other Aspects of Solar Design
- Building Orientation
- Building Form
- Relective Surfaces
- Landscaping Considerations
- Berming
- The Appearance of Solar Buildings

Buildings and sites planned for solar energy use sometimes differ in appearance from conventional projects, and solar houses using different types of solar energy systems look different from each other. Solar energy systems are usually classified as either active or passive. Hybrid systems combine features of both active and passive systems. All solar energy systems must have a means of collecting heat, transporting it to its point of use or storage, storing heat until it is needed, and controlling or regulating the amount of heat released to the various parts of the structure.

Active systems are characterized by the presence of solar collector panels, most commonly located on the roof of a building, although other locations are possible. An active system requires mechanical devices such as pumps or fans to transport solar-heated air or liquid to its point of use or to storage. (See Figure 1.)

Passive systems have no solar panels but rather rely on design or construction materials to collect the sun's heat. Passive systems have few, if any, mechanical devices and depend primarily on natural processes such as radiation, convection (air movement), or conduction (direct contact) to transport the collected heat. Passive systems often use windows, doorways, greenhouses, or skylights as solar collectors. Figure 2 shows a passive system using large south-facing windows as solar collectors. The windows convert sunlight to heat and store the heat in the walls and floors of the building. The heat warms the building by natural processes.

Solar energy system designs can affect a building's appearance. For instance, an active system uses solar collectors that are typically mounted on the building's roof or in the yard. In these locations, the collectors are highly visible features on an otherwise conventional building. Passive solar energy systems often require unconventional building design; many passive buildings use uncommonly large areas of south-facing glass to allow sunlight to penetrate into rooms. Some solar buildings integrate features from both passive and active systems, having collector panels on the roof and large glazed areas on the south wall.

Figure 1 A House Using an Active System

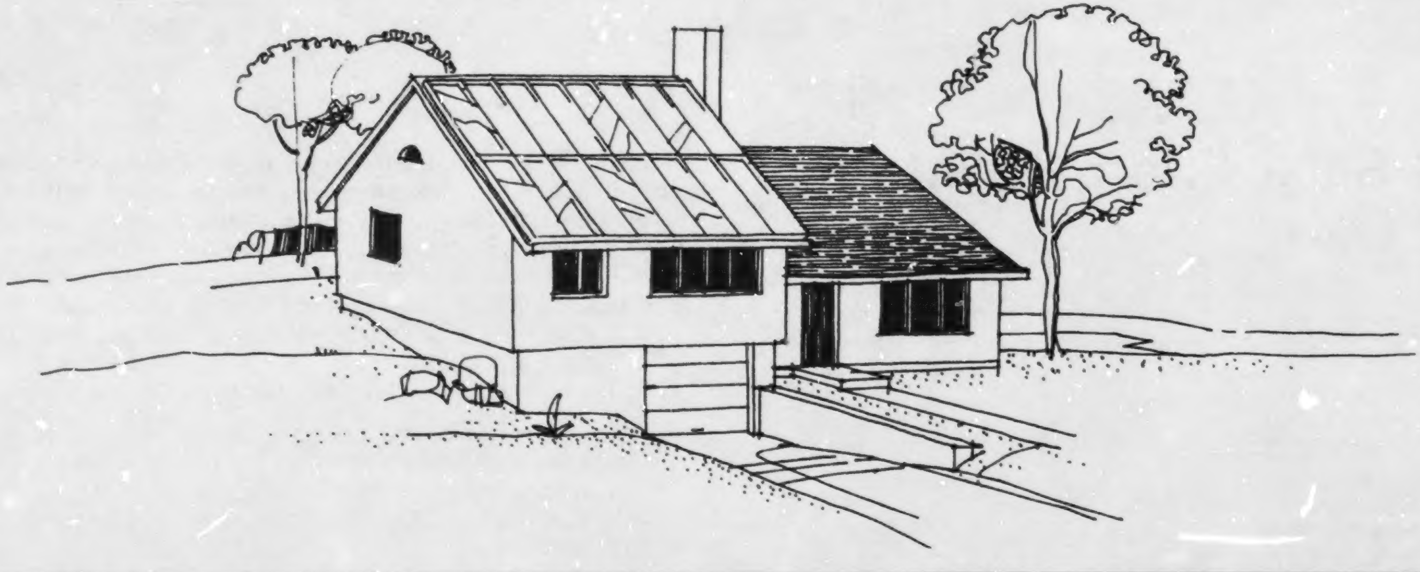

Figure 2 Passive Solar Heating

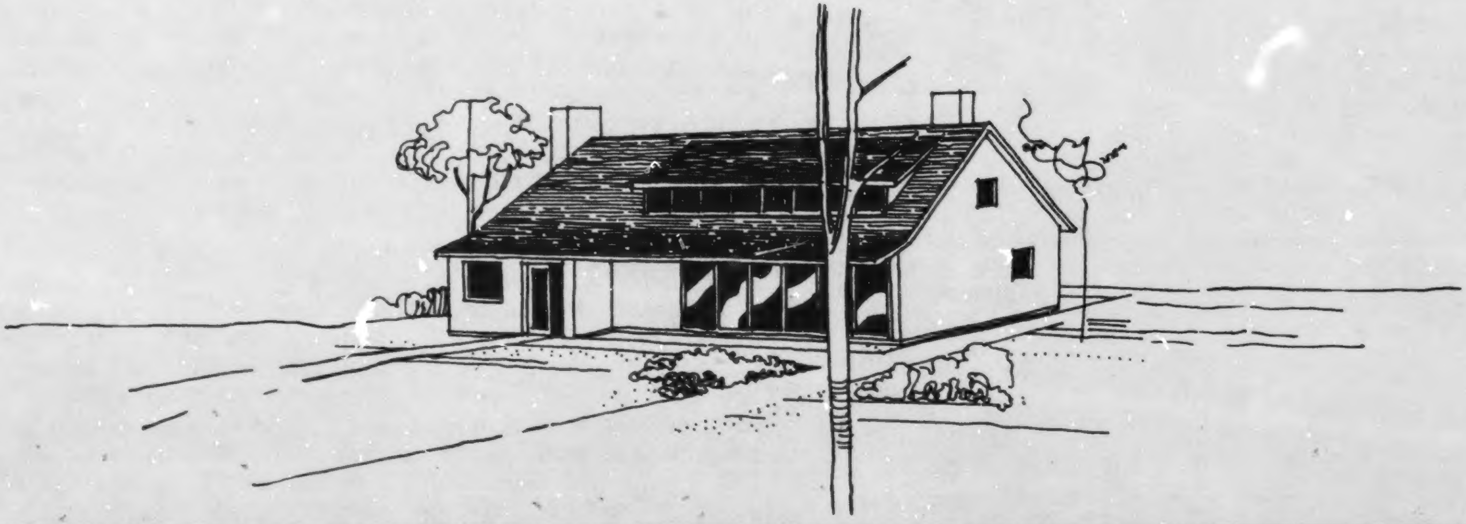

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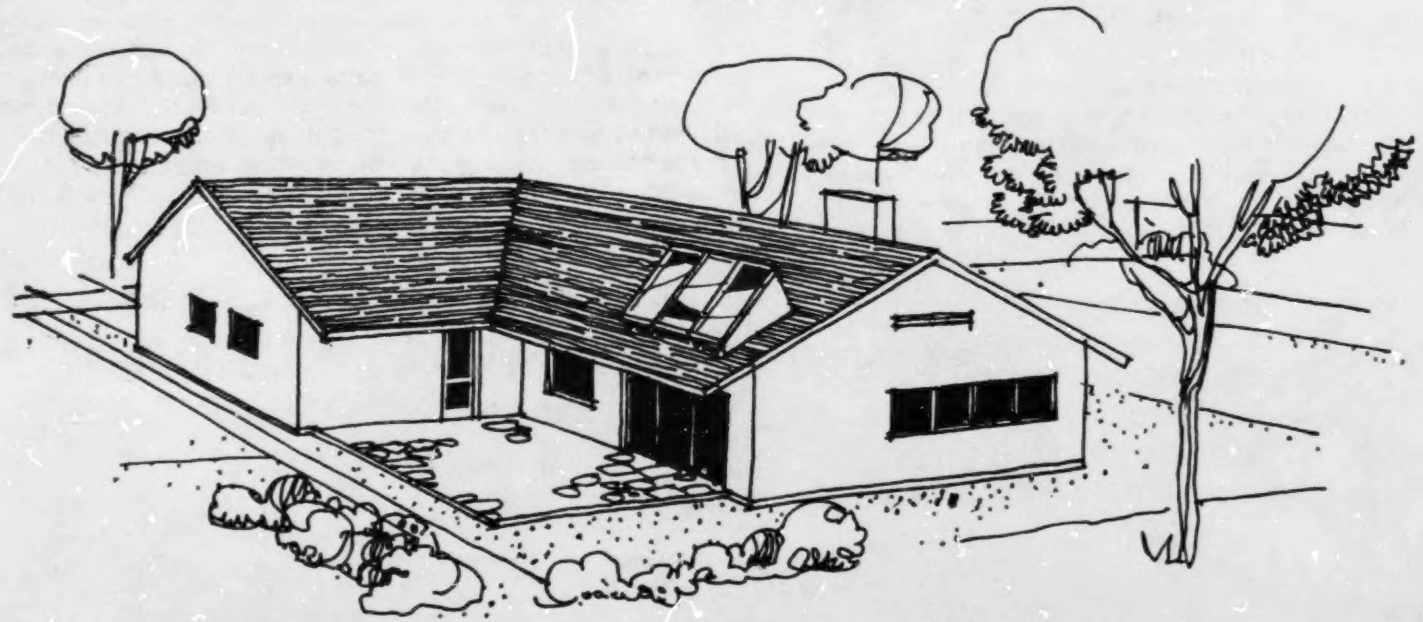
Figure 3 A Flat-Plate Collector Array



The storage component, which absorbs and releases heat, may also affect the exterior appearance of a solar building. In some passive buildings, mass walls, constructed of either masonry or water-filled drums and placed directly behind the south-facing glass, absorb direct sunlight. These dark-colored storage masses may be visible from the outside of the building. On the other hand, the storage components of active systems usually are located in places where they will be beyond the view of both occupants and passersby.

In some cases, the control mechanism which regulates the amount of heat entering the living area and the storage component will also alter a building's appearance. In active systems, the thermostats that often are used to operate fans or pumps are not obtrusive. Passive systems, however, must use devices to control the amount of heat that enters and leaves the building through the large windows. The window overhangs or awnings that keep out summer sun and the insulated windows, panels, shutters, or curtains that keep heat in on cold nights may be clearly visible from outside the building.

The next few sections discuss the appearance of solar energy systems and solar buildings in more detail.

Active Systems

The Collector

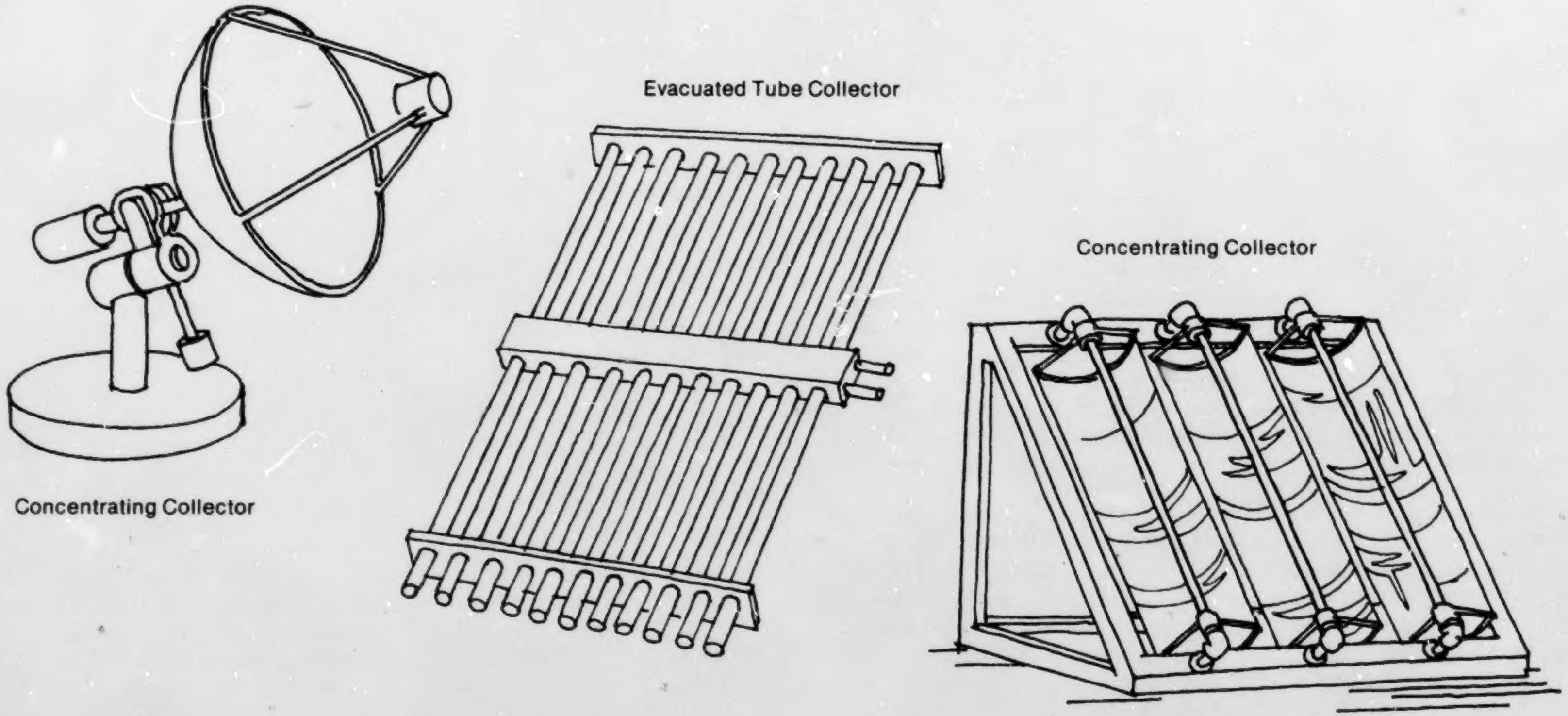
In both passive and active systems, the collector is the most visible part. As the connection between the sun and the rest of the system, it must be exposed to direct sunlight, and thus it is open to public view.

The most common type of active solar collector is the flat-plate collector. It is usually rectangular and is 3 or 4 feet wide, 6 to 8 feet long, and 4 to 6 inches deep. The collector is made up of several parts, the most visible being the top transparent cover and the dark absorber plate beneath the cover. A liquid or air is passed over or through the absorber plate and carries off the collected heat. Most collectors have flat cover plates, but some use curved plates. Flat-plate collectors are usually framed in wood, plastic, or metal and have an uncluttered appearance. Figure 3 shows what these collectors look like when installed on a building.

The other types of collectors that also can be used in active systems look quite different from flat-plate collectors. Some use evacuated tubes or reflectors to increase the amount of heat they generate. Evacuated tube collectors are installed in an array of connected tubes that has no cover plate but may have a reflective surface under it. Concentrating collectors are usually trough-shaped or concave disks. These other collector types are shown in Figure 4.

Buildings that use active solar energy systems to provide space heat or cooling do not differ in appearance from buildings that use active systems to heat domestic water; the only difference between them is the size of the collector array. Domestic water heating systems generally use fewer collectors than do space heating systems. In a moderate climate, the hot water needs of a family of four can be satisfied by two or three collector panels. To meet the space heating and cooling needs of the same building would require a much larger array, perhaps one that covers the entire south roof or south wall.

Figure 4 Other Types of Solar Collectors



The Location of Active Collectors

Collectors can be placed on the roof or wall of a building or on the ground next to a building. See Figure 5. Each of these locations affects the appearance of the solar equipment as well as the design of the building.

Most active collectors are located on the roof of the building they serve, in order to obtain maximum access to sunlight. A roof, furthermore, provides a solid, flat surface for anchoring the collector, and permits piping or ductwork to be run inside the structure, reducing heat loss.[1]

The appearance of roof-mounted collectors depends on several factors; most important is the size of the installation. If only a few panels are used for water heating, the building may look fairly conventional. If, however, the solar panels are numerous, they will dominate the roof of the building. For large installations, such as those used for space heating in cold climates, collectors may cover the entire roof, making it appear to be surfaced with dark-colored glass.

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[1] Proper installation techniques are described in the National Solar Heating and Cooling Information Center's Installation Guidelines for Solar DHW Systems, 1979.

Figure 5 Collector Locations

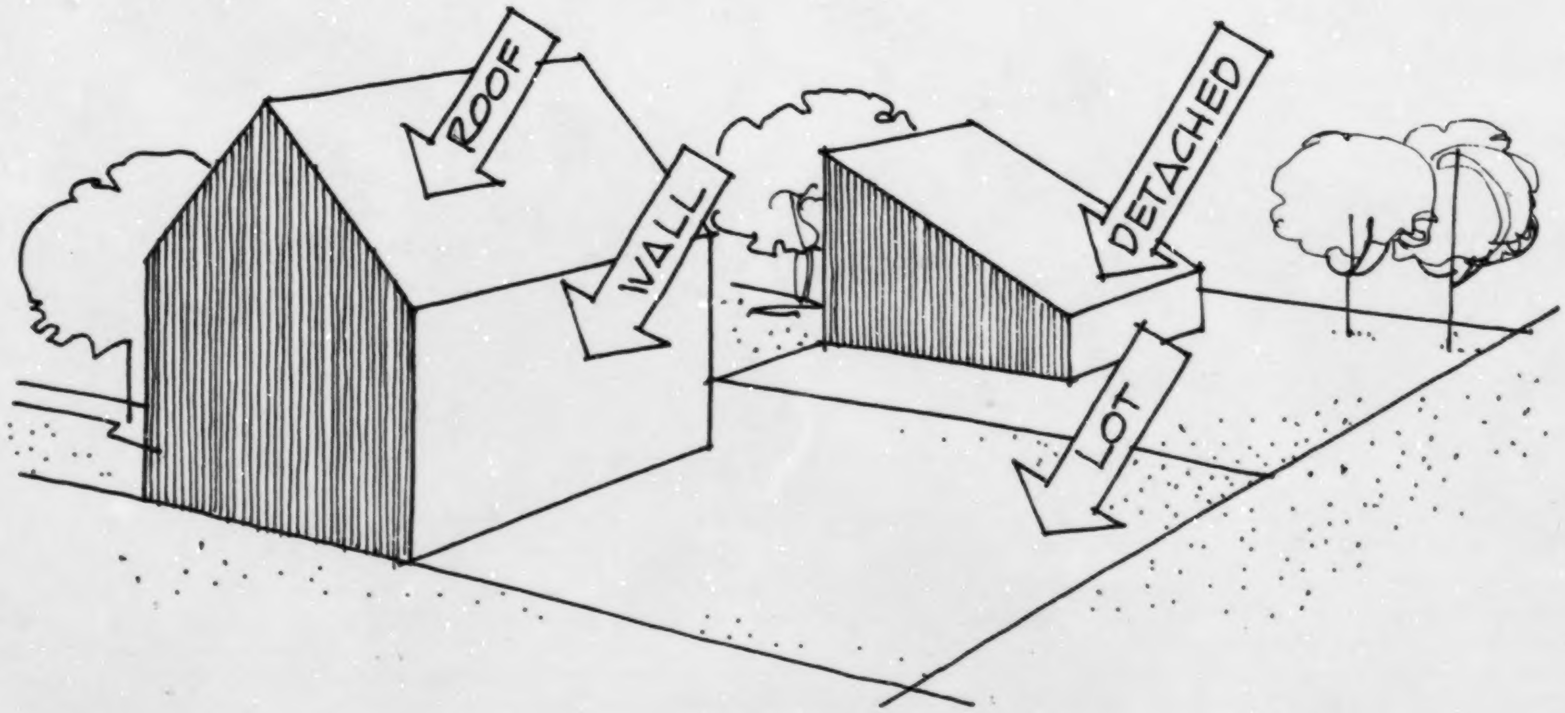
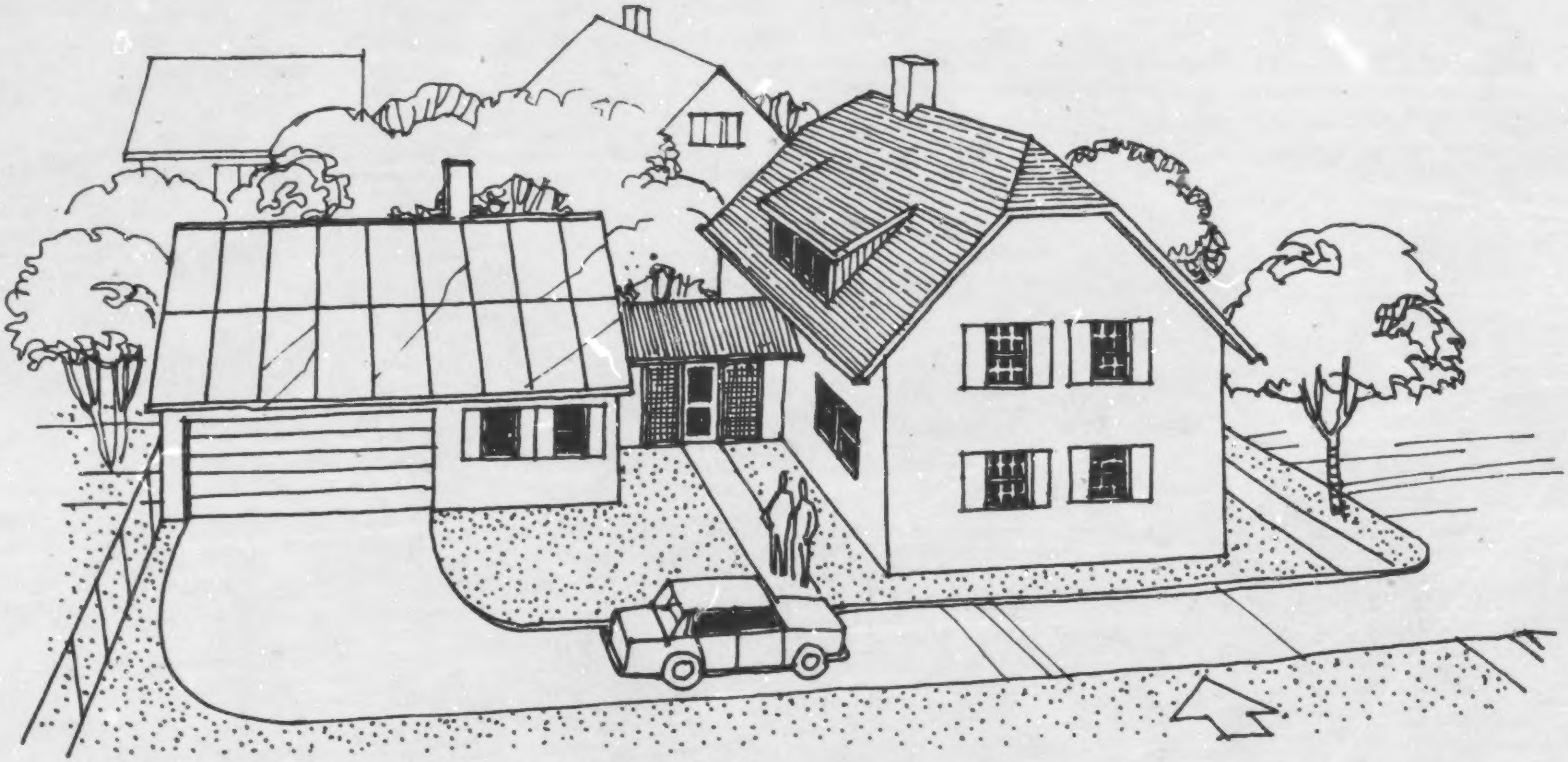


Figure 6 Roof Mounting on Accessory Buildings

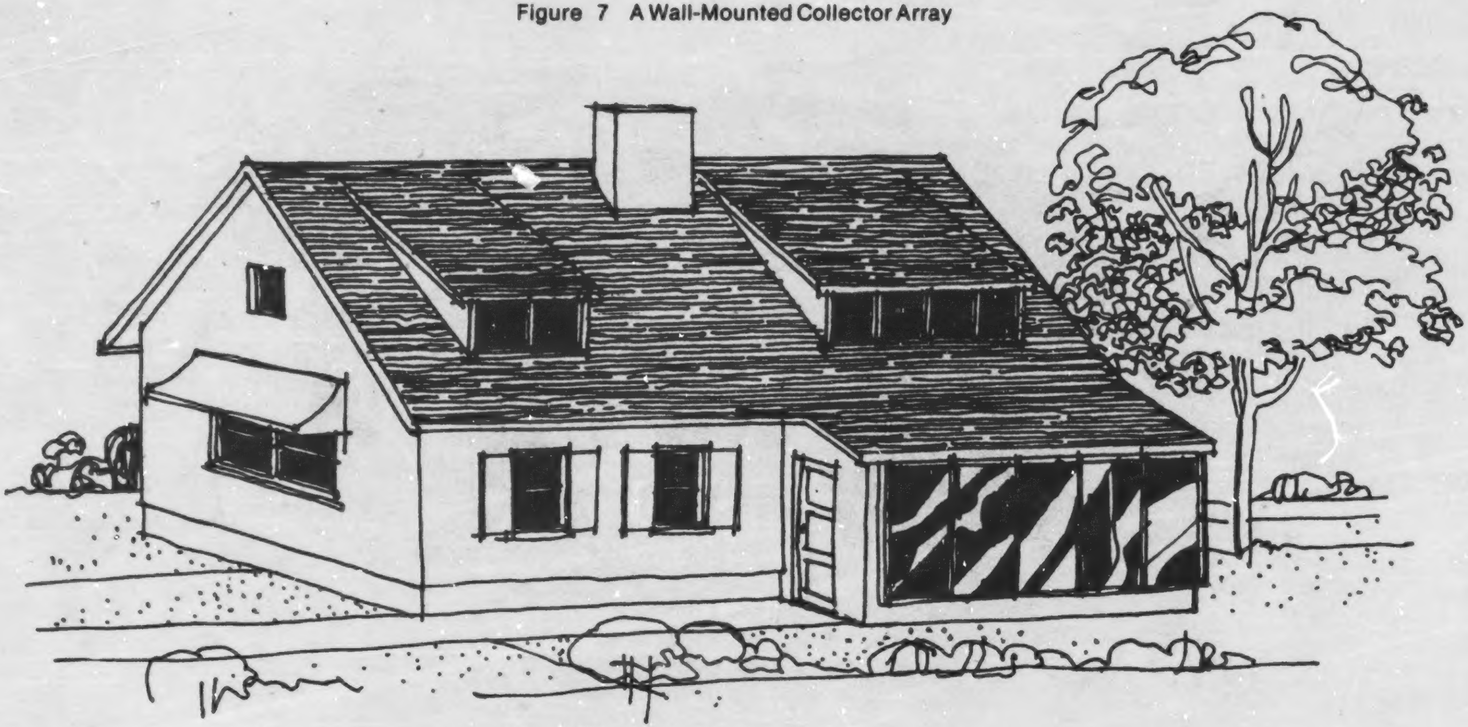


Depending upon the visibility of the roof surface, this may make the solar building look quite different from neighboring buildings.

Another factor that affects how roof-mounted active collectors look is the shape and orientation of the roof itself. Flat roofs present the fewest problems, since the collectors can be positioned almost anywhere on the roof and tilted up on a mounting to capture the sun's rays. It may be more difficult to mount collectors on pitched or sloping roofs. Where a roof peaks run east/west, a large area of the roof may be available for collectors, if the south-facing roof area is free from shadows. But complications can arise where available roof areas are not facing south.

When a roof is improperly oriented (generally not within 30 degrees of south), the collector can still be mounted so that it faces south. Mounting the collector in this manner, however, makes it so visually prominent that other collector locations often are chosen. Collectors can be located on a wall of the building, or even installed on the roof of an accessory building that is oriented in the correct direction. Figure 6 shows an example of this kind of roof-mounted sys-

Figure 7 A Wall-Mounted Collector Array



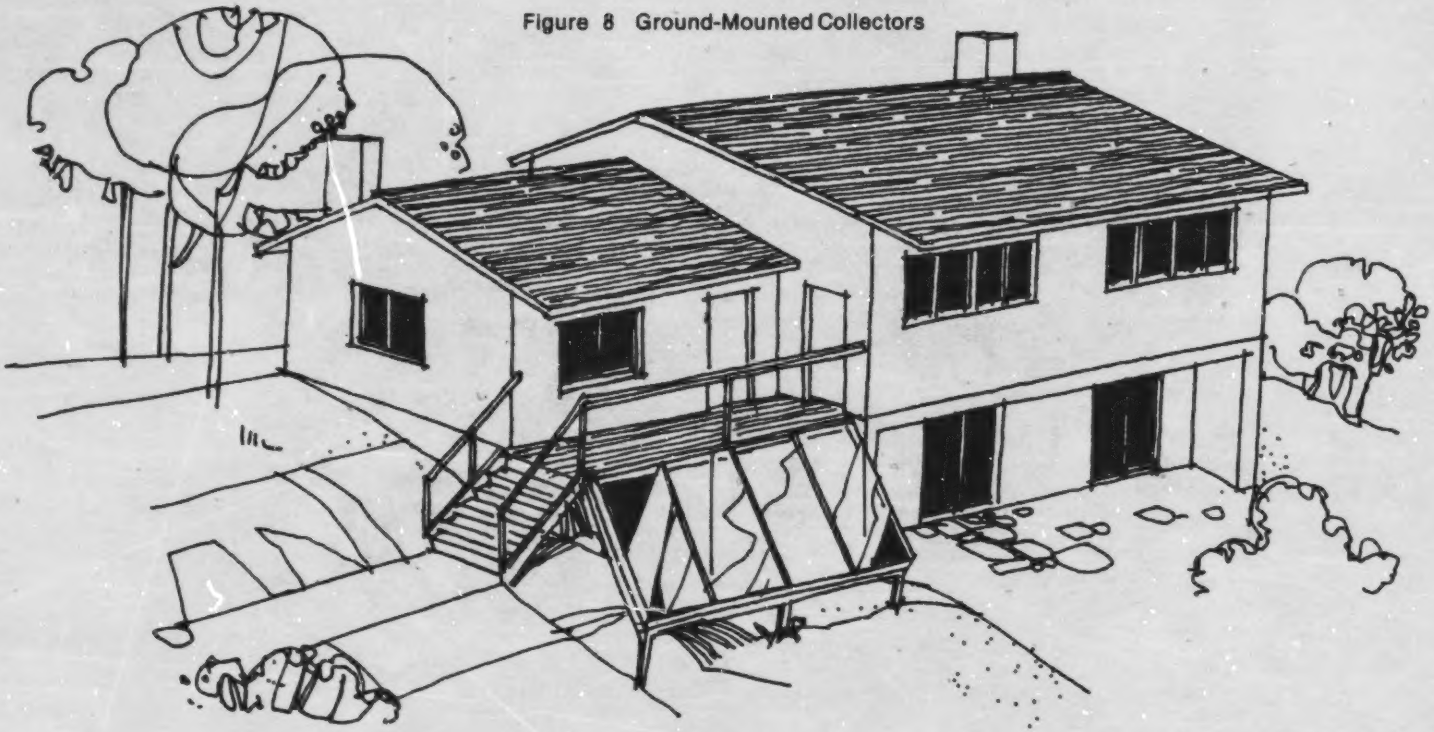
tem where a building's roof is not pointing south, but the roof of the garage is.

When there is other mechanical equipment on the roof, or the roof faces the wrong direction, or it is shaded, active collectors can be located on a south wall of a building. A south-wall installation generally works best in northern climates—at high latitudes where the winter sun is low in the sky and strikes vertical walls very directly. Figure 7 shows this type of installation on a single-family house. The collectors are installed on a south-facing wall free from shading. In this example, the collectors cannot be roof-mounted because of the dormers, and wall mounting provides a good alternative location.

Collectors can also be mounted on the ground next to a building. Like collectors mounted on a flat roof, ground-mounted collectors should be tilted on a frame to best capture the sun's rays and must be faced south. They can also be mounted on natural earth mounds (berms) which have been sloped at the proper angle and face south to provide good orientation for the collectors. Figure 8 shows an example of a ground-mounted collector installation.

The major disadvantage of ground-mounted collectors is that they must be located close to the building that they serve to avoid heat loss during transport. In addition, they are susceptible to shading and may present safety problems. Review board members should realize that these limitations make some ground locations inadvisable for collector installations.

Figure 8 Ground-Mounted Collectors



Flush and Raised Installations

Active collectors can be purchased already made, or they can be custom-designed for a particular building and fabricated at the construction site. The type of collector chosen can affect how the collectors will be installed on a building's roof and how the installation will look.

Ready-made collectors, installed on top of a completed and shingled roof, are usually elevated a few inches above the roof surface on treated lumber or angle iron mounts; this elevation allows rain and snow to drain beneath the installation. On a new roof, however, collectors often are installed over the roofing paper and flashed in as part of the roof surface. Flashing and caulking must be done carefully to prevent leaks. A third approach is to build the collectors into the roof, so that the surface is flush with the surrounding roofing materials. This approach is most often taken with custom-designed, site-fabricated collectors.

Elevating the collectors above the roof surface gives them greatest prominence but can be an effective design technique to emphasize the contrast between the collectors and the roof. The surface-mounting approach maintains the contrast between materials and surface levels, but without making the collectors quite as prominent. Flush mounting minimizes the prominence but also reduces the clear delineation between the collectors and the roof, limiting the potential use of the solar system as a design element. (See Figure 9.)

Plumbing and Ductwork

An active system transfers heat in a building by using a fluid—a liquid or air that circulates between the collector and the other components of the system. This circulation requires plumbing or ductwork to carry the heated water, air, or other fluid from the collector to the living area and storage. If the system uses a liquid, pipes are used. If it uses air, ductwork is used.

Usually the piping or ductwork is not visible. Pipes or ducts (called inlet and outlet manifolds) connect each collector in an array and pass through the roof at some point. Locating these manifolds beneath the roof surface is impractical for many surface- or rack-mounted collectors because it would require two breaks in the roof surface for each collector instead of two for the entire collector array. (See Figure 10.) Multiple roof penetrations substantially increase the likelihood of leaks and the expense of installing the system.

Most of the time, the plumbing can be easily covered by a wood or plastic casing to conceal the pipes or ducts; the covering also

Figure 9 Roof-Mounted Active Collector Arrays

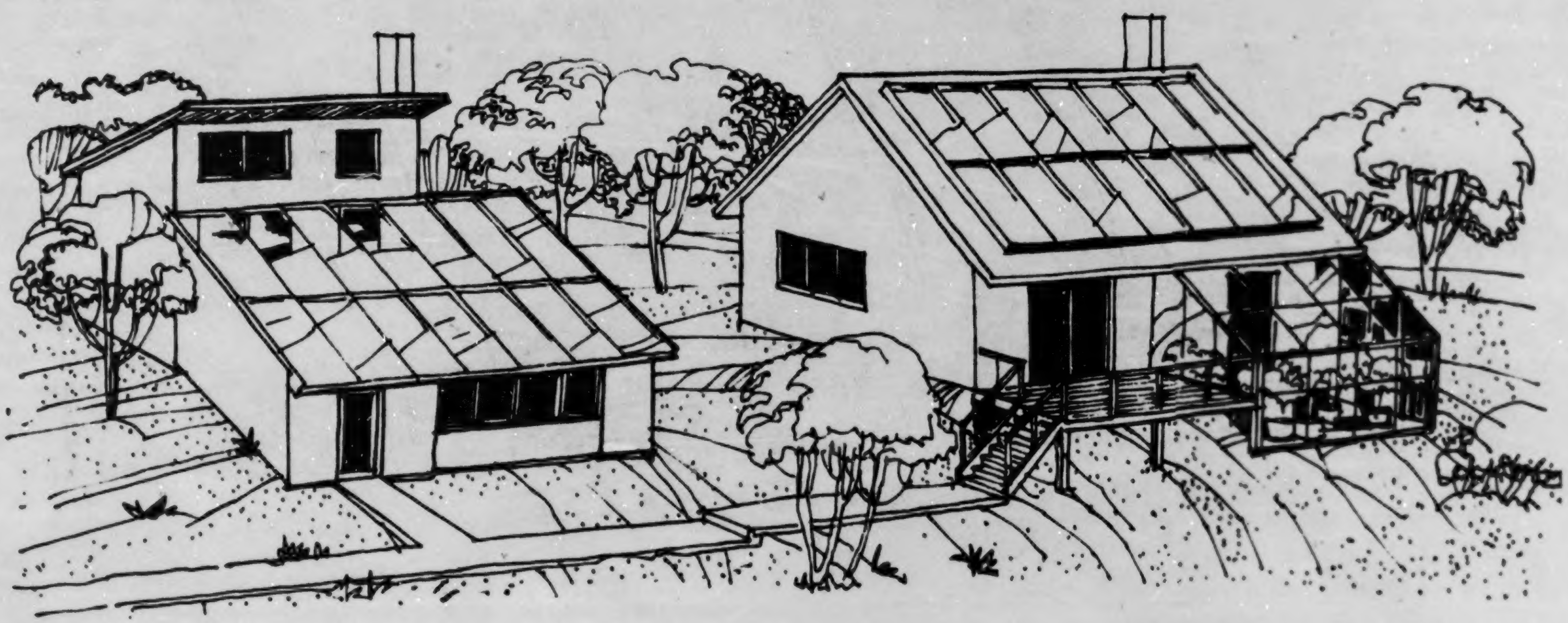


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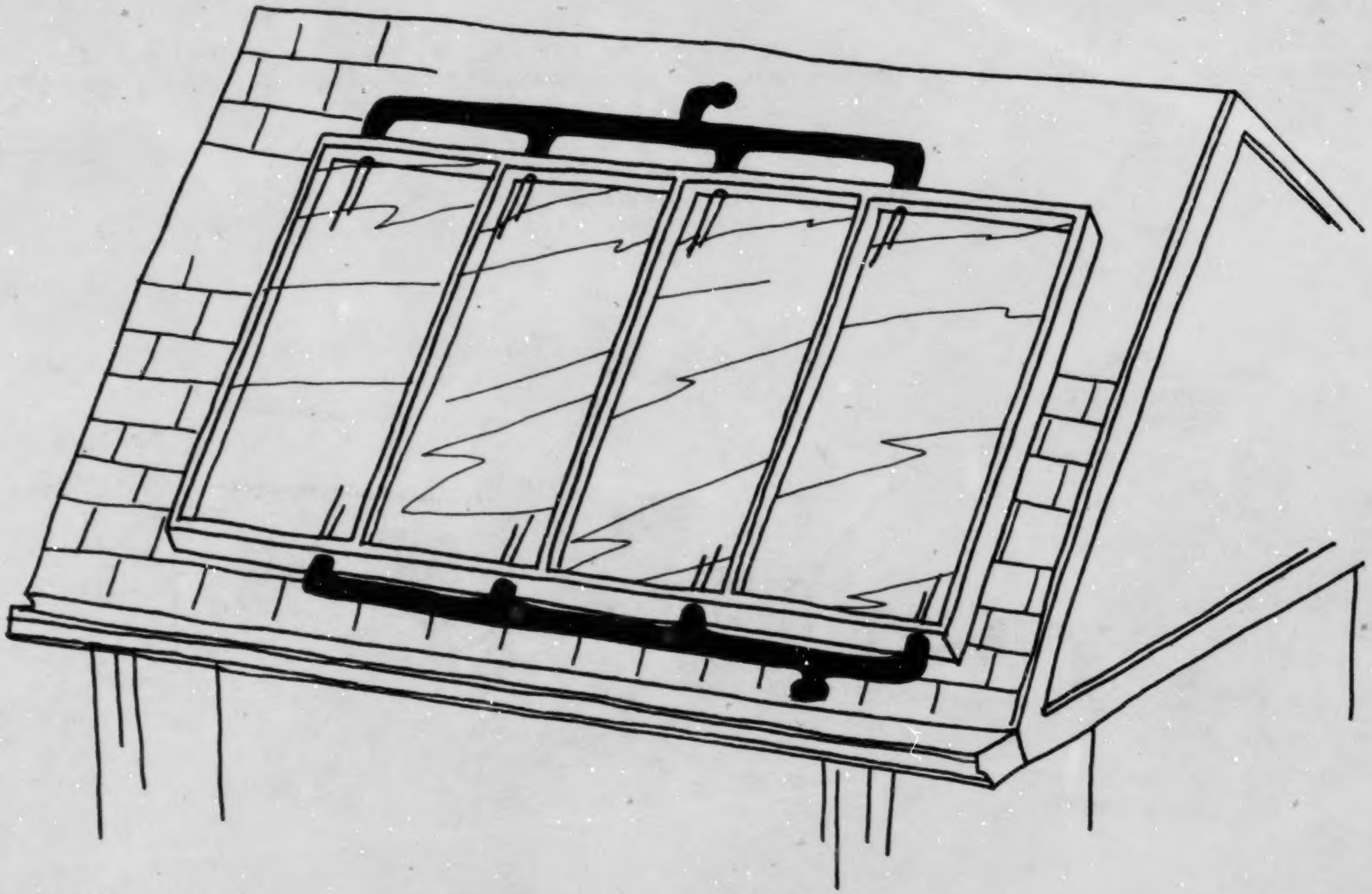
Figure 10 Collector Piping



serves as insulation. The exposed piping or casing is often painted to match or blend with the edge of the collectors or with the building's materials or trim. In addition, plumbing at the top of a roof-mounted collector is often partially concealed if the collector is raised. The collector itself conceals the manifold from ground level. Some collectors are also designed with internal manifolds which minimize field piping or ducting connections.

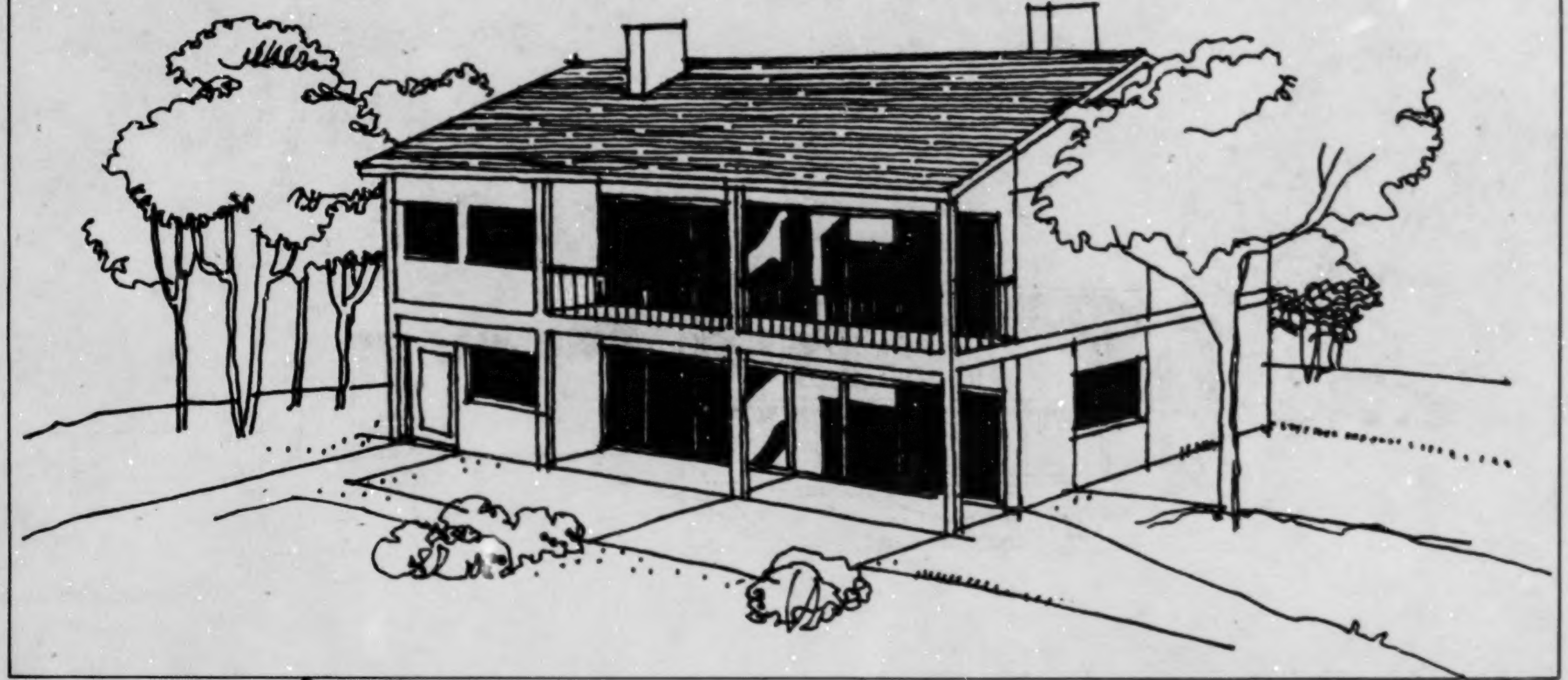
Passive Systems

The Collector

Unlike the add-on, mechanical collectors in active systems, collectors in passive solar energy systems are an integral part of the building that they heat. They may have a greater effect on how a building looks than those in active systems, because they are an integral part of the building rather than a mechanical component attached to the building. Passive collectors often are large south-facing windows, skylights, clerestory windows, or greenhouses.

Passive heating systems commonly are categorized as direct gain, indirect gain, or isolated gain (greenhouse) systems. Direct gain systems use south-facing glass to admit sunlight into the living space, where sunlight is converted into heat as it strikes the interior surfaces. The heat is stored in the room's walls and floor. At night, the south glass is covered by an insulating panel or curtain that reduces heat losses. Figure 11, an illustration of a passive house using a direct gain system, shows a good example of this type of building.

Figure 11 · A Direct Gain Passive House



In the second common type of passive solar systems, indirect gain systems, sunlight enters south-facing glazing and strikes a storage mass (either masonry or water) behind the window. The masonry wall is located behind the glazing and is vented to allow warm air to enter the living area of the building. In summer, the warmed air is vented to the outside through the glazing vents. Figure 12, below, shows what this type of building can look like.

The third type of passive system is known as an isolated gain system. The glazing and storage mass are outside of the building, and the heat is vented into the building when needed. At night, the glazing is covered by insulated panels to reduce heat loss to the cooler night air. A solar greenhouse, which looks like a conventional greenhouse attached to a building, is an example of this type of passive system. A schematic of a solar greenhouse is shown in Figure 13.

Figure 12 An Indirect Gain Passive House

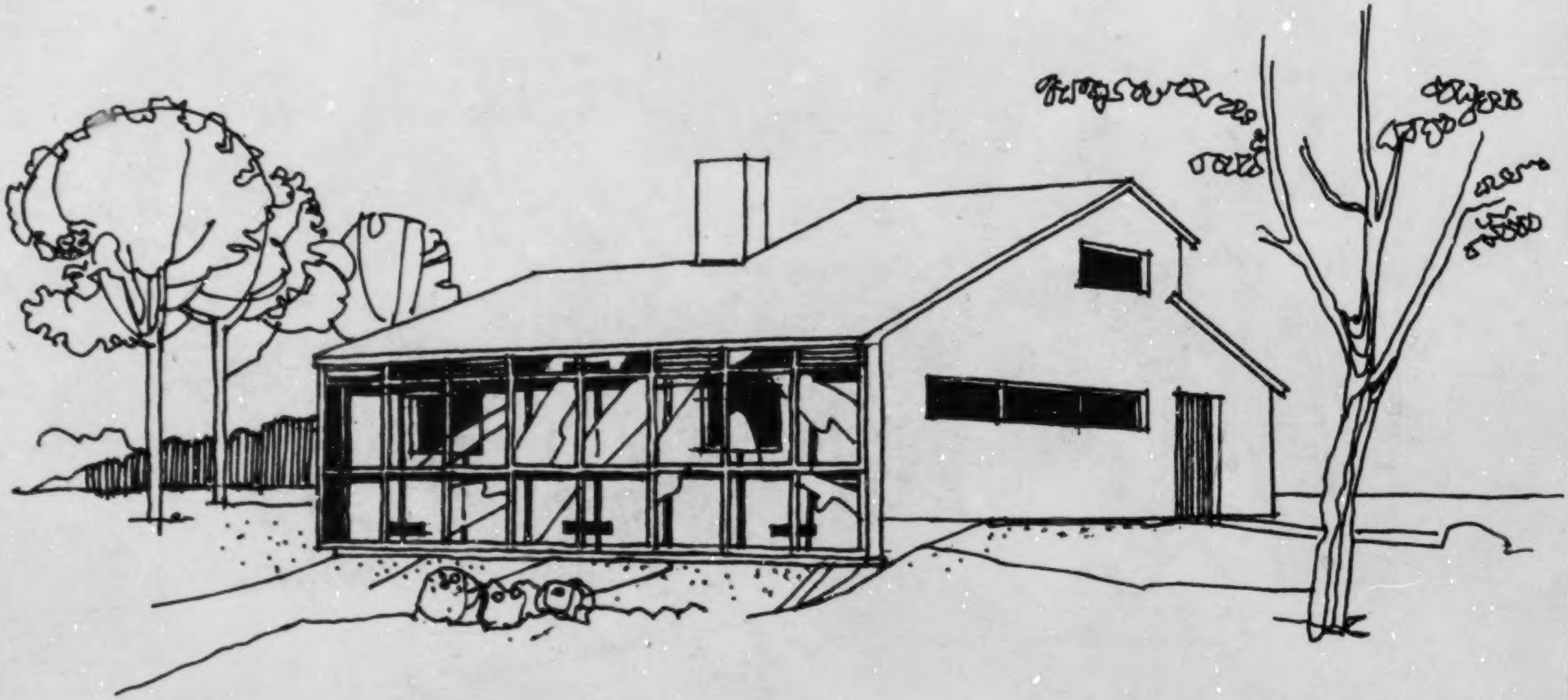
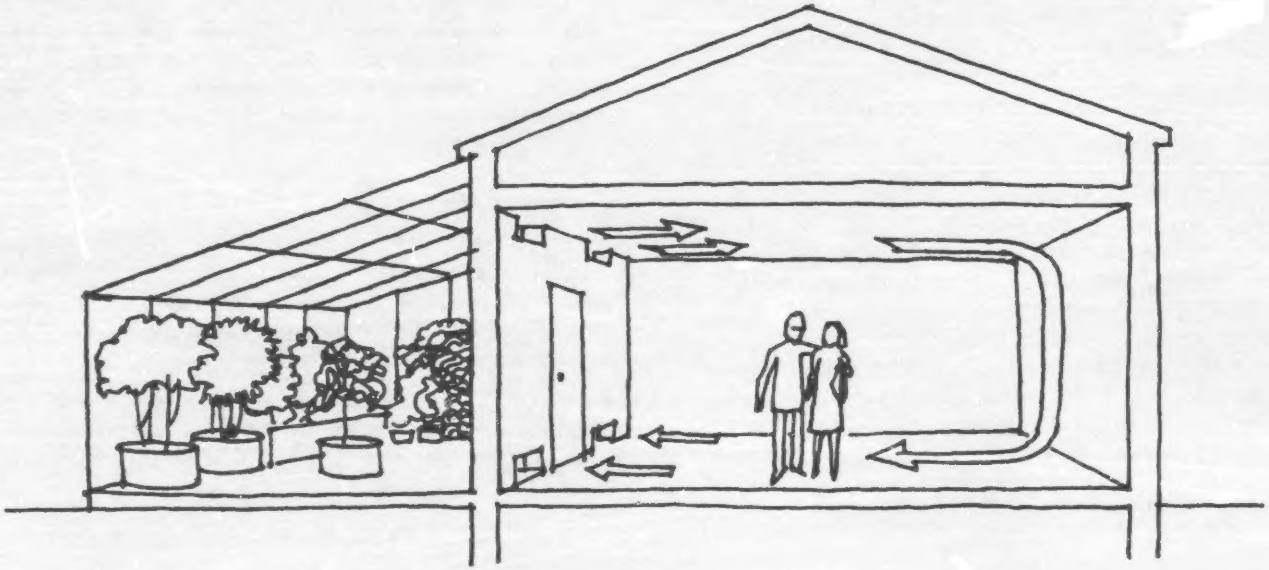


Figure 13 A Solar Greenhouse



A greenhouse is an especially useful means of retrofitting an existing building with a passive solar system. Greenhouses are aesthetically acceptable to most people and, when properly located and built of compatible materials, they can add significantly to the appearance of most buildings.

Passively heated houses and buildings do not necessarily have to look different from conventional buildings. Designers of some passive buildings combine contemporary styles with extensive areas of glazing on south walls to highlight the special function of the structure as a heating system. But other styles of buildings can also be considered, using conventional building materials and roof shapes.

Generally, passively heated buildings have more glazing on south-facing walls than on other walls. The size of this glazing depends on technical factors such as the amount of heat that the system is designed to provide, the climate, the amount and type of thermal mass used for heat storage, and the methods used to insulate the glazing at night. In some installations, the south glazing may be quite prominent, especially if the glazed area is larger than the windows of neighboring, conventionally heated buildings. But in some extremely well insulated buildings designed with proper glazing insulation and thermal mass, there may be little difference between passive buildings and conventional ones in the size of south-facing windows, especially in milder climates.

Architects consider several factors, besides technical ones, in the design of the glazing for passive solar projects. Larger panes of glazing or collector panels mean fewer joints, less framing, and reduced costs. Less framing, in turn, means that there is less shading. On the other hand, larger panes or panels must be thicker to withstand high winds and are more expensive to replace if broken. A large expanse of glazing, using a few individual panes or panels, will permit the use of a large storage mass. However, the final configuration of the glazing and the placement of storage will depend on the interior design of the building and on its thermal characteristics.

Collectors in a passive system and ordinary windows also differ in the type of materials used for glazing. Glass is probably the most common material used in passive systems, and often the glazing consists of two or three layers of glass to minimize the loss of heat from the building. This glazing can be used in several ways—as large picture windows, sliding doorwalls or patio doors, dormers and skylights, and other types of installations that are commonly found in non-solar buildings. These installations probably will not look different from the types used in conventionally designed buildings. Some passive system collectors use plastic materials instead of (or with) glass. Transparent or translucent plastics increasingly are being used as glazing, and often they are corrugated to increase their strength. Some of the plastics are less expensive, lighter, and stronger than glass, but the use of such materials causes additional aesthetic problems for design review boards.

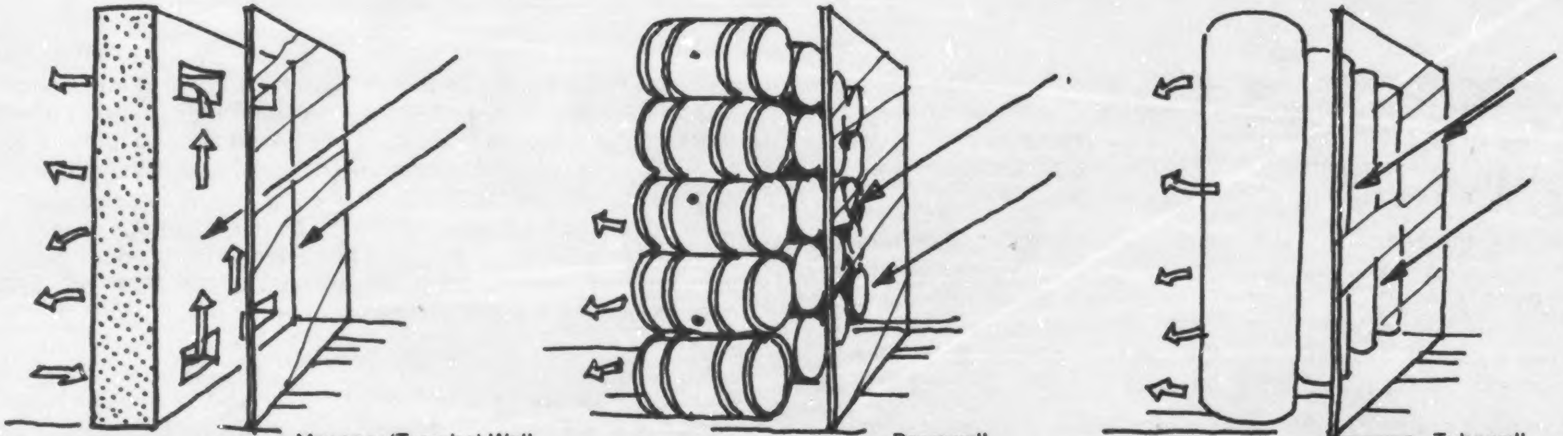
The orientation of solar buildings greatly affects their appearance to passersby. When passive collectors face the street, solar buildings may look very different from conventional buildings. When extensive glazed areas face backyards, however, passive systems are not noticeable to pedestrians and motorists, but the system may still be visible to neighbors. In active systems, the collectors can be mounted separately or shifted to face the sun independently of the building's orientation.

Passive System Storage

Because passive storage masses must receive direct sunlight, passive solar energy systems often have storage units that can be seen through the collector glazing. In an active system the heat is moved by pumps or fans to the storage component, which can be hidden in a basement or closet.

Several types of storage units are used in passive systems; stacks of water-filled drums, masonry walls, or columns filled with water are usually located immediately behind the passive glazing. (See Figure 14.)

Figure 14 Thermal Storage Units



Masonry (Trombe) Wall

Drumwall

Tubewall

Masonry floors or room walls can also be used to store heat, but these do not affect the appearance of a solar building in the same way that the other types of storage do.

Visible storage masses influence the appearance of indirect gain buildings. The drums, columns, or walls that are immediately behind the glass are unusual architectural features and may be clearly visible through windows. In contrast, a masonry floor or an interior wall for storage has a more conventional appearance. Furniture, plants, or other decorations, rather than drums or columns, are visible through the glass.

Panels, Shutters, and Curtains

The glazing of a passive solar building must be insulated when sunlight is not coming in; otherwise, heat will flow from the warm interior to the outside through the glass or plastic glazing. Insulated panels, shutters, or curtains are used to keep this heat inside the building at night or on cloudy days. These devices can be located inside or outside of the glazing. Shutters and panels are usually made of wood with a core of plastic foam, a good insulating material. They may open from the sides, top, or bottom of the glazing. Of course, exterior shutters are more noticeable than those mounted on the inside of the collector.

Shading Devices

Devices that keep out unwanted sunlight in the summer are important features of passive solar buildings. Since these buildings have large south-facing windows to catch the sun in winter, the windows must be shaded in summer, when the sun is much higher in the southern sky. Awnings, trellises, or carefully sited vegetation can provide needed shade during the summer and also admit winter sunlight to the passive glazing.

An overhang is the preferred solution. The distance that an overhang extends can be calculated to provide summer shade and to let in winter light. Although latitude determines how deep an overhang must be, in most locations the overhang does not have to be very wide. In fact, in many instances, the overhang will not differ from the eaves commonly used on conventional buildings. Review boards should know, however, that overhangs are very important to the efficient operation of passive systems.

Passive Domestic Hot Water Systems

Passive systems can be used to heat water for domestic use as well as to heat and cool space. There are two types of passive hot water systems—breadbox and thermosyphon. The breadbox system consists of drums and water inside an insulated box that is opened during the day to expose the drums to sunlight. The diagram in Figure 15, shows the system opened. The thermosyphon looks more like an active system. Flat-plate collectors heat a liquid that rises by natural movement to a storage tank. The tank must be located above the collectors and often is inside the building. Figure 15, illustrates both types of systems.

Passive Cooling Systems

In some climates, passive technologies can be used to cool buildings as well as to heat them. Two approaches are common—one uses evaporation to cool the living area, and the other uses sunlight to create cooling air currents.

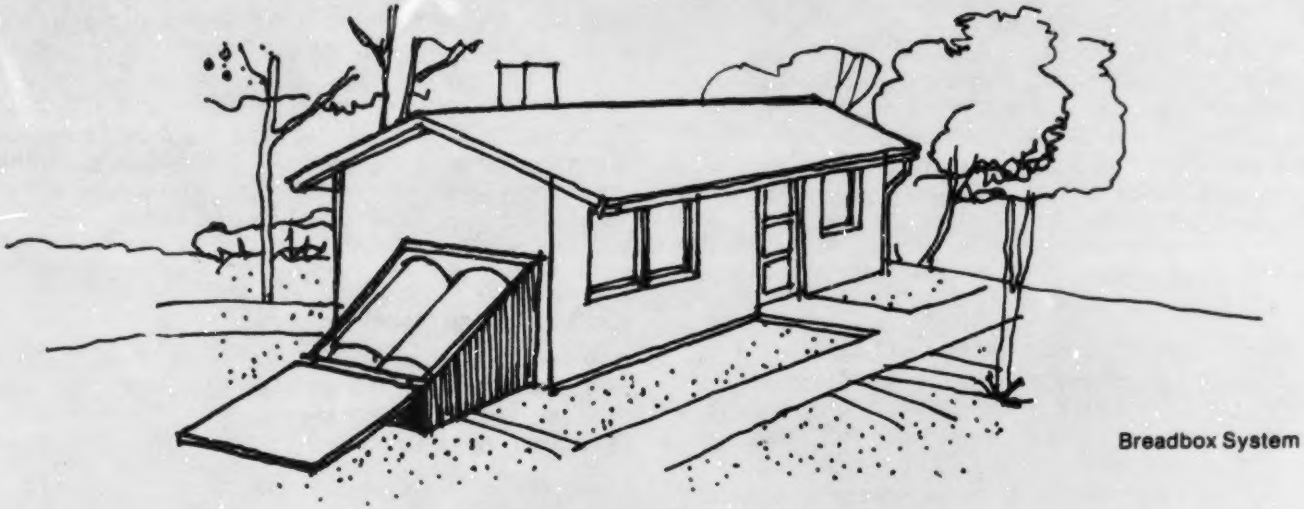
Evaporative cooling systems, used in hot, arid climates vary in appearance. The simplest of these systems is merely a sprinkler system on the roof of a conventional building. During a hot day (or night), the water evaporates off the roof shingles and cools the building. A more sophisticated system uses a specially designed pond of water located on the roof to cool the building. Often a series of louvers shades the roof pond; this shading minimizes heat gain to the pond, while it admits breezes that evaporate the water. This system type is most often installed on flat-roofed buildings, and the louver apparatus may be visible from outside the building. Figure 16 illustrates a roof-pond system. A variation of this approach is to place the roof-pond in a plastic container (like a waterbed); radiation releases the heat to the night sky and cools the building.

The second type of passive cooling system is called an induced-draft system. It uses a special chimney that is heated by sunlight to create an updraft that pulls a breeze through the rest of the building. Sometimes called a solar chimney, this system is shown in Figure 17.

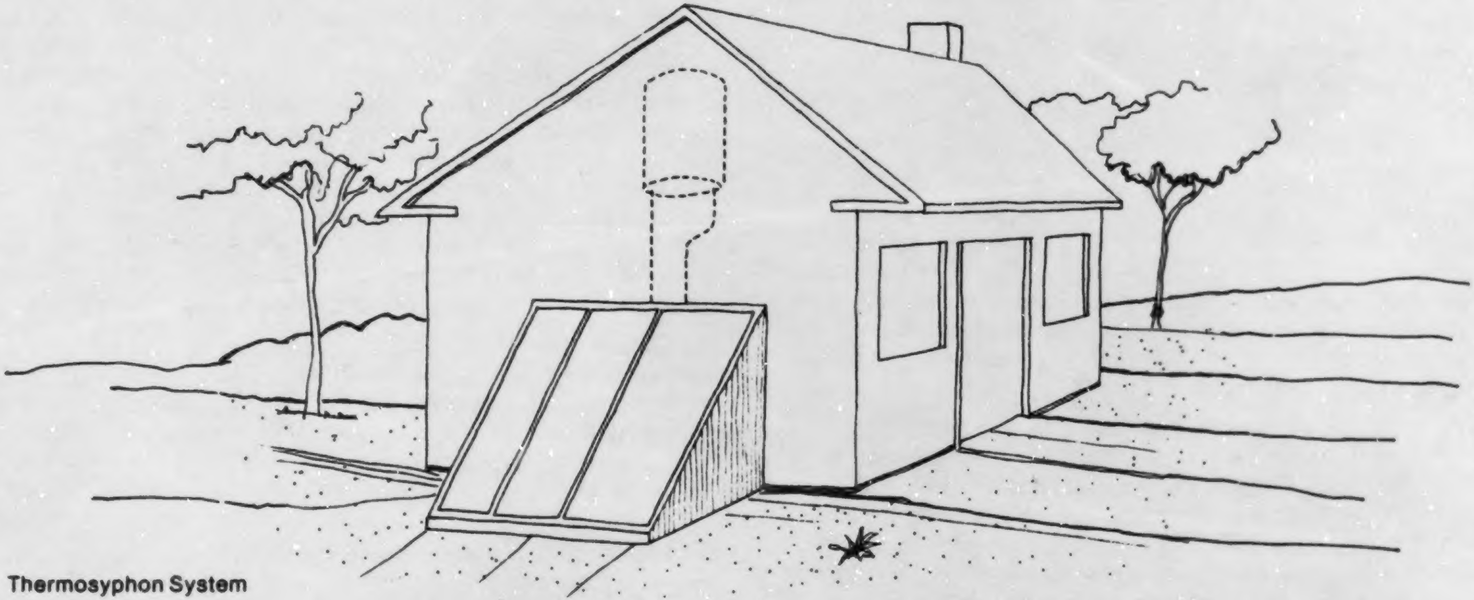
Other Aspects of Solar Design

Up to this point, we have discussed how the components of solar energy systems may differ in appearance from conventional building

Figure 15 Passive Solar Water Heaters



Breadbox System



Thermosyphon System

Figure 16 Passive Evaporation Cooling System

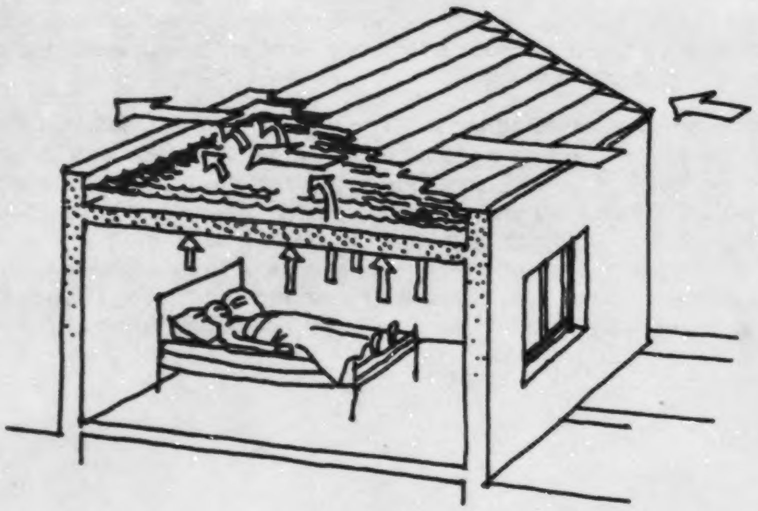
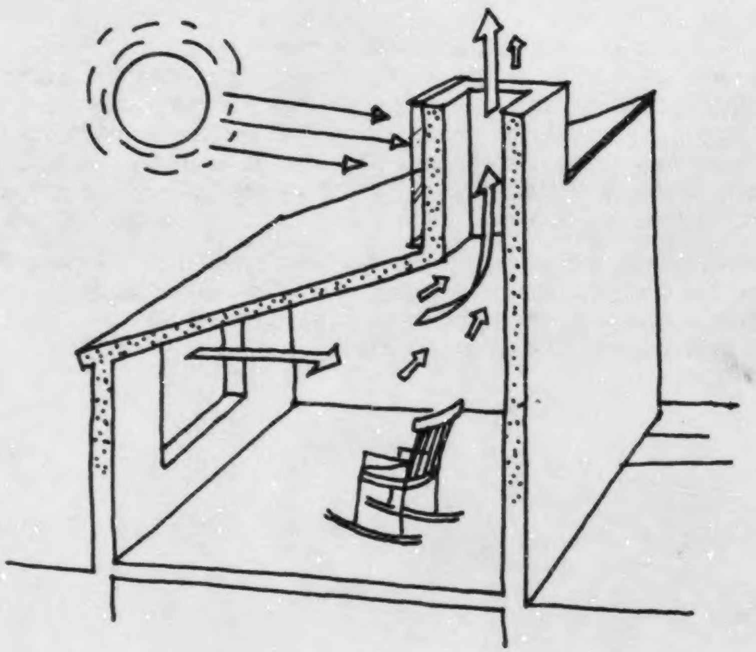


Figure 17 Solar Chimney



elements. The actual hardware—the collectors, transport mechanisms, and storage units—is only one part of solar design. For the solar system to work well, the building and the yard around it must be designed to enhance the use of the solar system. These design considerations include some obvious, but important, goals: to orient the building in a manner that takes full advantage of winter sun and protects it from summer sun; to minimize heat loss from the building in winter; and to protect the building from winter winds and to use summer breezes to cool the building.

While some strategies for reaching these goals will not influence how a building looks, others will directly influence the form of the building, how it is placed on a lot, and the type of landscaping that is used. This section discusses these externally visible features.

Building Orientation

For both warm and cold climates, the best heat gain and loss conditions occur when a building is oriented with its long axis in an east/west direction. This is true for conventional as well as solar buildings, but it is particularly important to solar-heated or cooled structures.

With the building's long axis running east/west, the largest expanses of walls and roofs are oriented south. This orientation captures the maximum natural heating from winter sun and provides the necessary surfaces for glazing or for locating active collectors. Equally important, this orientation reduces overheating in the summer. The east and west walls of the building receive the most intense sunlight in the summer; an east/west orientation minimizes the amount of wall surface that will be heated during summer mornings and afternoons. Figure 18 illustrates this point.

In some situations, orienting the largest surfaces to the south conflicts with the standard practice of a neighborhood and, therefore, may be of concern to design review boards. On north/south streets the longest facade of the building will not be parallel to the street; it will be perpendicular. On streets or lots that are neither north/south nor east/west, it may be necessary to site the buildings at an angle. Figure 19 shows how solar homes could be sited on a street running northwest and southeast.

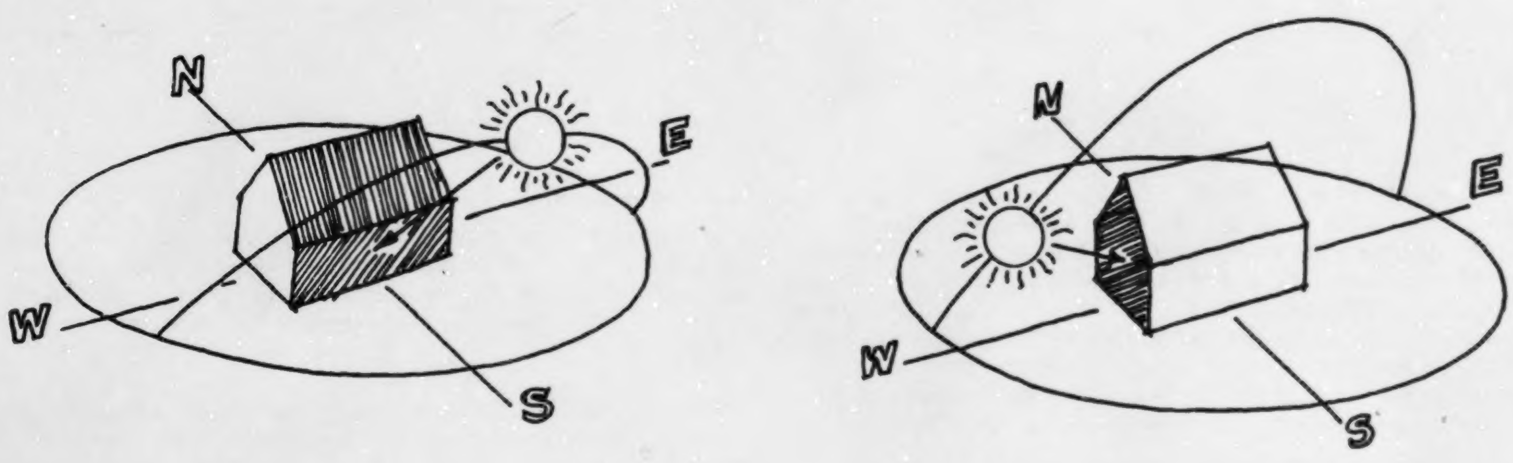
It should be remembered that this southern orientation is extremely important for buildings using solar energy. The next chapter discusses solar buildings whose major facades do not face the street and shows that such breaks with traditional practices need not be obtrusive.

Building Form

As the previous section suggests, the use of solar energy influences considerations about building form. The solar architect wants to maximize southern surfaces and minimize those facing east and west. In addition, the architect considers some other aspects of building form including the amount of exterior wall area in relation to interior floor area, the placement of windows, and the color and pitch of the roof.

Minimizing exterior surfaces. In cold climates, the architect will try to minimize heat loss by reducing the area of exterior wall and roof surfaces. This design technique influences the type of building that is built. Often it is better to use a compact design, such as a two-story house, rather than to have the same amount of floor space spread out on a single story. Row houses or low-rise multifamily houses are even better because they can have exposed southern walls yet share east and west walls with adjoining houses.

Figure 18 Solar Orientation



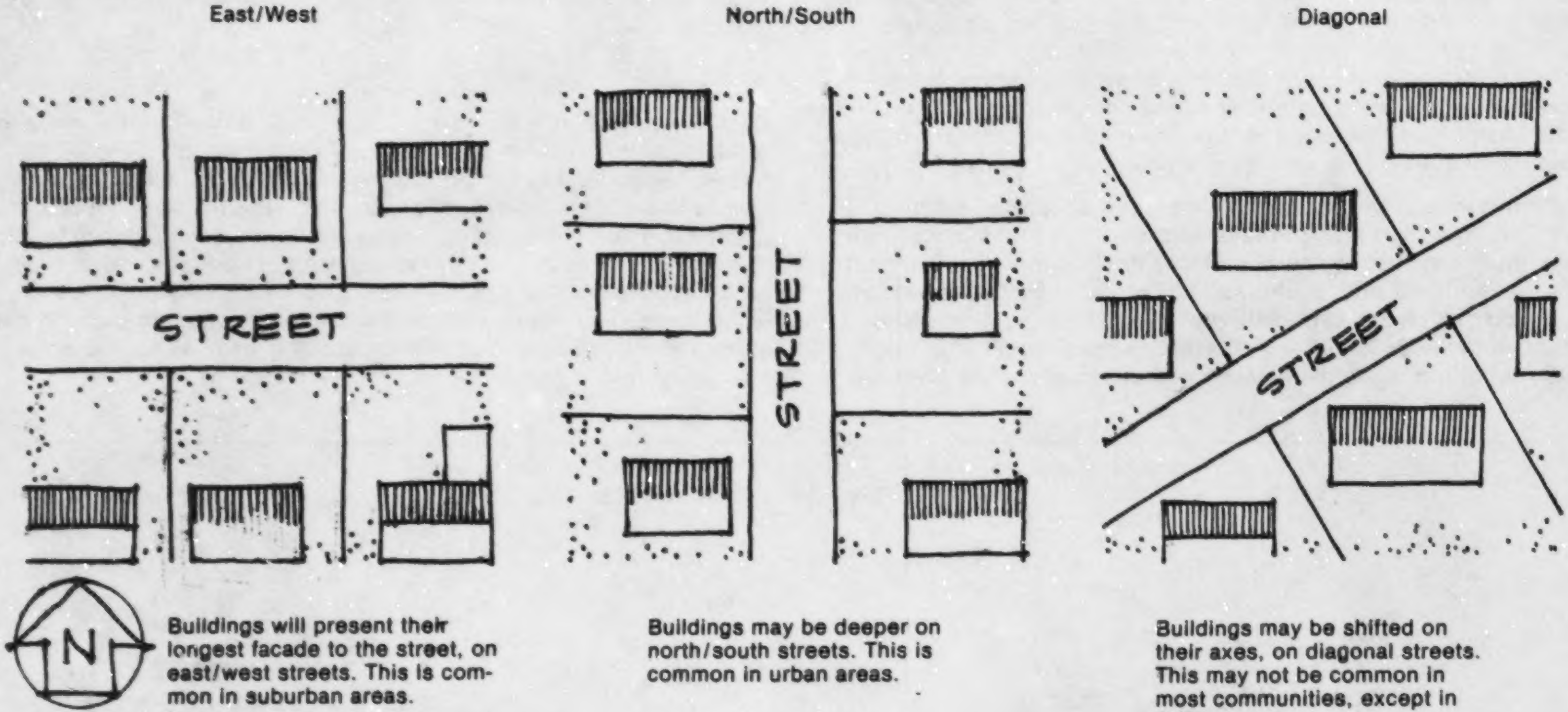


Figure 19 Building and Street Orientation

Buildings will present their longest facade to the street, on east/west streets. This is common in suburban areas.

Buildings may be deeper on north/south streets. This is common in urban areas.

Buildings may be shifted on their axes, on diagonal streets. This may not be common in most communities, except in PUDs.

Few windows on the north, east, and west. The need to minimize exterior surfaces is directly related to the need to limit the number and area of windows that do not face south. In winter, the building will lose heat more quickly through the glass than through the walls. In summer, the east and west windows will be particularly troublesome because of the hot sun; since the sun is lower in the eastern and western sky than in the southern sky, overhangs cannot shade east or west windows as effectively as they shade south windows.

The configuration of windows depends upon the building, the particular climate of the site, and the individual preferences of the owner. North windows may be important for natural light, and they can be used; but double or triple glazing is necessary to insulate them. East and west windows may be important for summer ventilation, particularly in warmer climates, but adequate shading is needed to protect them from direct sunlight. East and west windows may also be desirable for the sake of the view.

The number and arrangement of windows affect a building's appearance. Architectural review boards should consider the heat-conserving advantages of some unconventional arrangements.

The color and pitch of roofs. Roof color and pitch are important for buildings that use solar energy. The color of the roof can enhance a building's energy efficiency. In climates where the need for heating is greater than the need for cooling, dark-colored rooftops may, if steep enough, absorb solar energy (like the collectors) and may add some of this heat to the building. In climates where cooling is important, light-colored rooftops reflect sunlight away from buildings and reduce the need to cool them. Design review boards that enforce requirements for certain roof colors should consider the implications of roof color for energy conservation and for the needs of buildings that use solar energy systems.

Roof pitch is also important for roof-mounted collectors because pitch determines how much the collectors will be tilted up towards the sun. Surfaces that are perpendicular to the sun's rays will gain solar radiation more effectively than horizontal or vertical surfaces. Solar buildings that are expressly designed to use roof-mounted collectors may be built with more steeply pitched roofs than might normally be found on conventionally heated housing. For example, a building located at 40 degrees north latitude (New York City's approximate latitude) should have a southern roof pitched at a 50 to 55 degree angle. This tilt will best expose the solar collectors to sunlight so that they can absorb the most solar radiation for winter heating. Collectors designed for domestic hot water or cooling should have lesser slopes.

Reflective Surfaces

Some solar buildings use part of the roof or some other surface as a reflector to direct more solar energy to the collectors. Figure 20, below, shows how reflectors can be used. The building on the left uses a flat roof surface to reflect sunlight upward to a roof-mounted active collector; the building on the right uses a light-colored patio to reflect sunlight through passive glazing. In both cases, the surface can be painted a light color or covered with a shiny material (such as aluminum) to increase the amount of sunlight that the collector receives. The use of reflectors can greatly assist the solar energy system.

Figure 20 Building Features Used as Reflectors

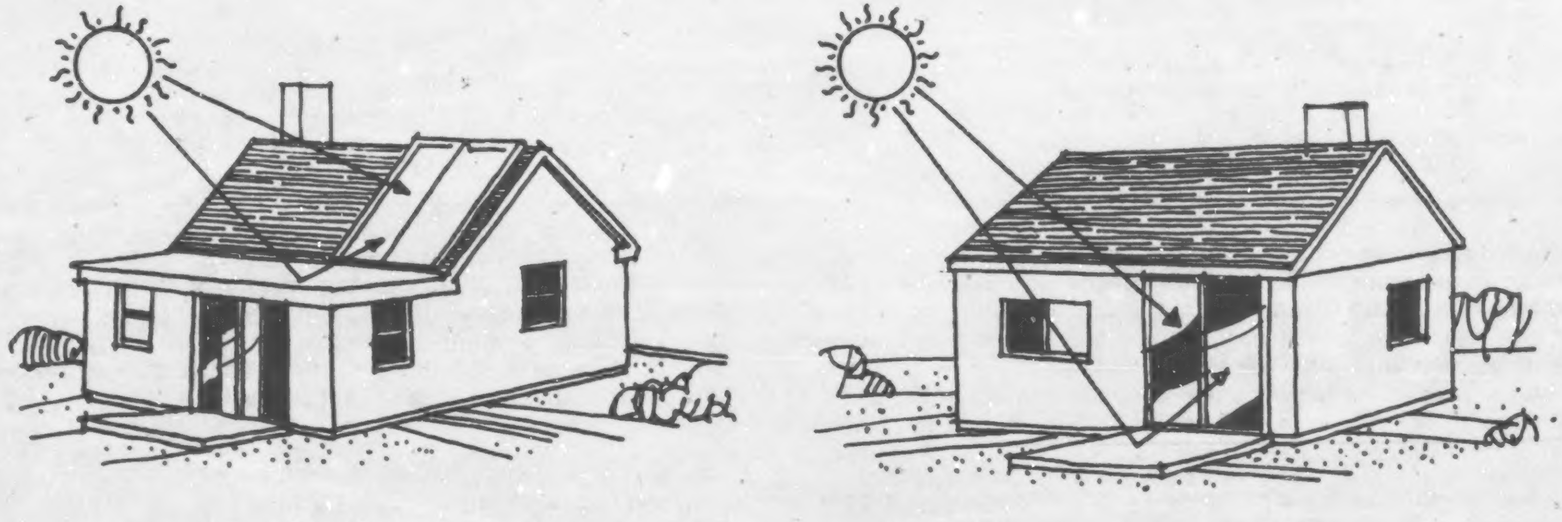
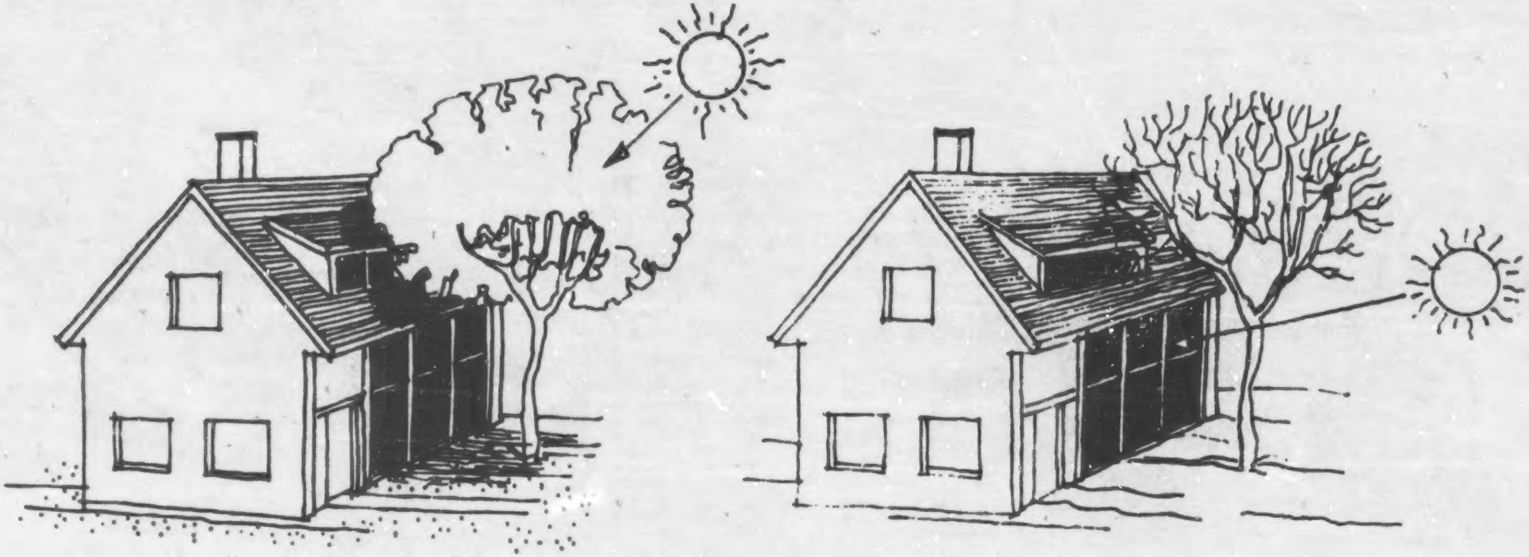


Figure 21 Tall Trees on South Exposures



Landscaping Considerations

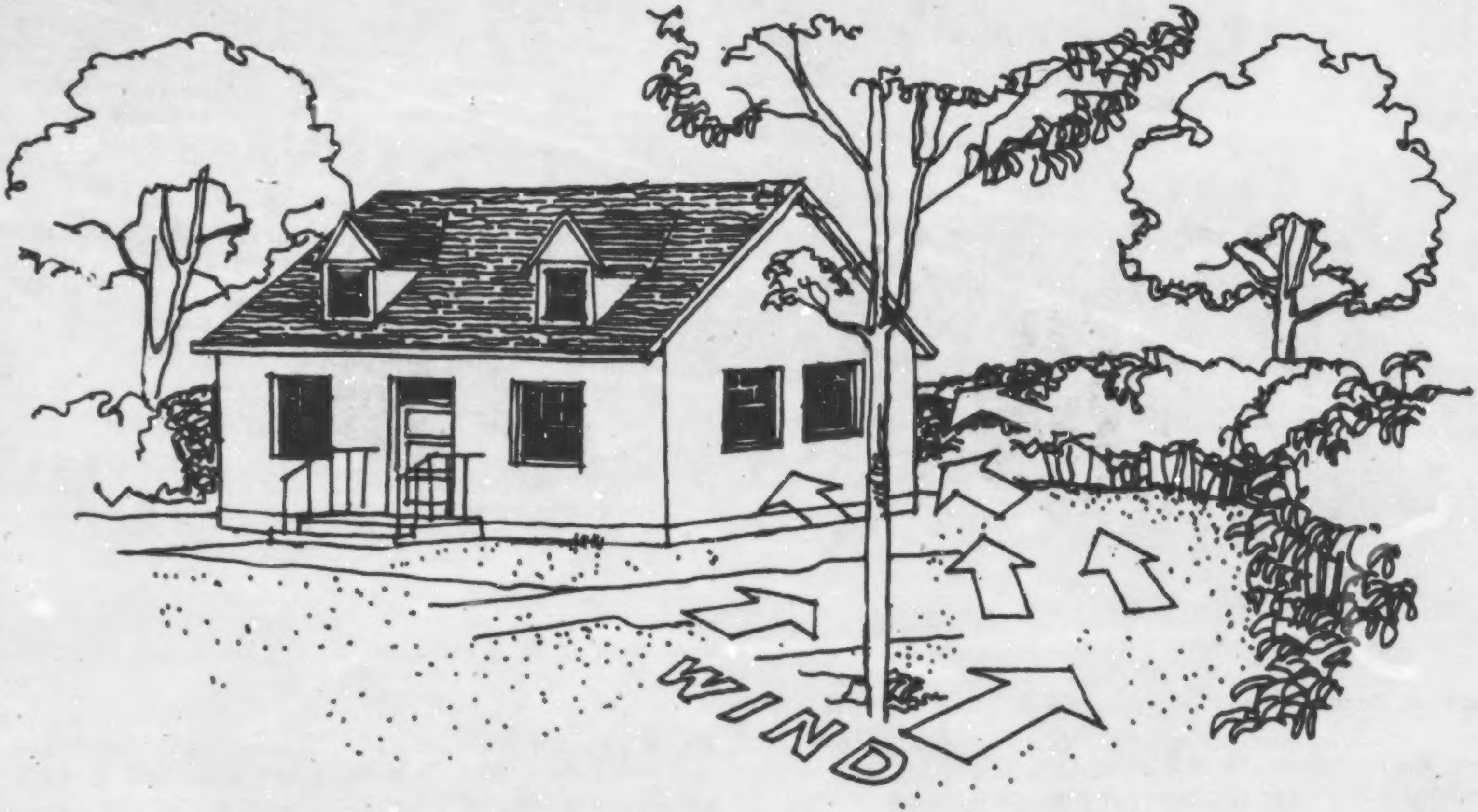
Site design for solar buildings requires special attention to landscaping. The location of plants and trees can be planned to enhance energy conservation and still permit unobstructed access to direct sunlight. Landscaping is often used to buffer wind and thus to conserve energy in the building, but trees and other vegetation must be located so they do not shade solar collectors.

Balancing energy-conservation and solar access needs can mean that the landscaping around a solar building will differ from that of a conventional building. Often, vegetation that is close to the building will be concentrated near the east, west, and north walls, leaving the south wall and roof open to the sun. This practice means that the east and west walls, which receive the most solar radiation in the summer, are properly shaded.

Placing vegetation, especially evergreen species, near the north and west walls buffers the building from cold winter winds. To avoid shading collectors, tall vegetation usually is not located in the area of a lot from the southwest to the southeast of the house. Deciduous trees, which allow light in winter and shade in summer, can be located quite close to the south wall without impairing solar access too much. (See Figure 21.)

In warmer climates, vegetation can be used to channel cooling breezes. Often, buildings that use solar energy are designed to take advantage of natural ventilation. Figure 22 shows how hedges can serve both to divert breezes through buildings and to decorate the site.

Figure 22 Landscaping Used to Channel Winds



Berming

Like vegetation, berms—built up masses of earth—can be used to insulate or buffer a solar building from the elements. The berms are piled up against the walls of the building and then usually sodded. Conventional houses sometimes have this type of treatment as a result of construction or landscaping practice. For a solar building, the most likely locations for berms are the north, east, and west walls. (See Figure 23.)

Figure 24 shows a berm that is used as a base for a ground-mounted collector. The berm is constructed so that it provides the collector with proper orientation—that is, facing south and tilted up at a certain angle. The berm may be landscaped on the north, east, and west sides to blend into the rest of the lot landscaping.

Figure 23 Using Berms for Insulation

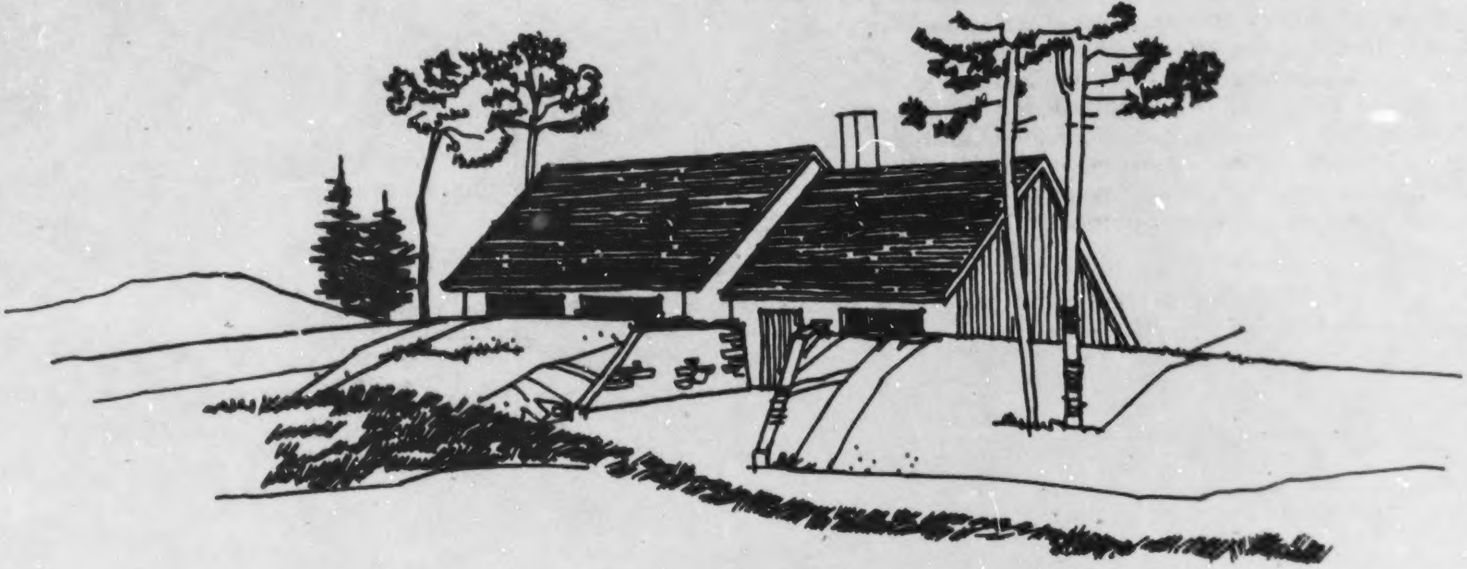
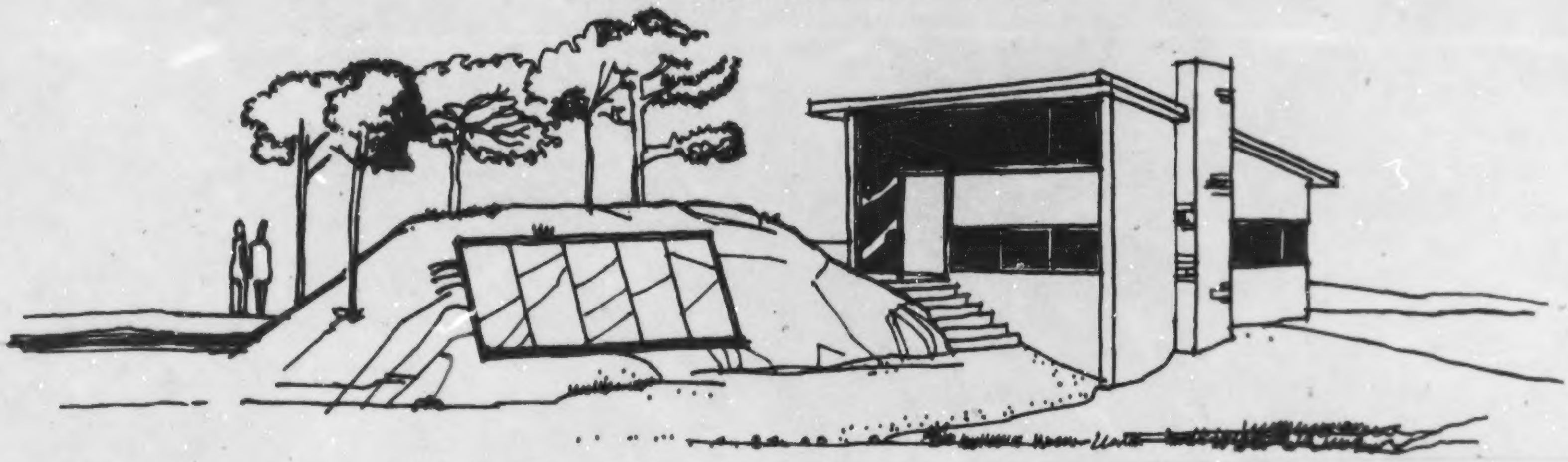


Figure 24 Using a Berm as a Collector Mounting



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The Appearance of Solar Buildings

The technical requirements of solar energy use imply that solar buildings must look different from conventional buildings. While the solar equipment, the shape and form of a building, and the preparation of a site all affect solar energy use and the appearance of a building in its setting, solar features or installations do not impose rigid aesthetic restrictions. There is considerable flexibility in designing both the building and the solar energy system. The next chapter discusses how designers or architects can combine common solar design features to achieve a particular design objective.

Design Strategies for Solar Buildings

Concealing Solar Collectors or Solar Features
- Roof and Building Orientation
- Parapets
- Setting Collectors Back from Sight Lines
- Landscaping and Fencing
- Berming
- Using Building Features to Conceal Passive DHW Systems

Integrating Active Collectors Into Buildings
- Emphasizing the Collector Array as a Design Feature
- Covering Building Surface with a Collector Array
- Balancing Solar Installations and Building Features

Integrating Passive Collectors Into Buildings
- Minimizing the Prominence of Extensive Passive Glazing
- Integrating Unconventional Glazing Materials

Highlighting Solar Features
- Roof Pitch, Size, and Materials
- Accentuating Collector Mountings
- Accentuating the Mechanical Character of Solar Installations

Integrating Solar Buildings Into Neighborhood Settings
- Compensating for the Lack of Windows
- Using Design Elements from Surrounding Buildings

This chapter shows how the design of solar energy systems can be flexible and can be accomplished to meet a variety of objectives. The premise of this chapter is that an architect or solar designer has a great deal of latitude in designing solar energy systems and the buildings that use them. Often, it is the design rather than the technology of solar energy use that determines how a design board judges a building.

Solar buildings do not have to look alike merely because they use solar equipment or solar design features. Different solar energy systems can be installed on a building of a specific style or design, and buildings of quite different appearance or architectural style can use the same types of solar equipment. Whether a solar building is deemed aesthetically desirable depends as much on how the solar energy system is installed or placed on the building as it does on the appearance of the individual solar components or features of the structure.

Designers generally have three broad alternatives for using solar energy in residential building design. The solar features of a building can be concealed; integrated into the design of the structure; or highlighted as a prominent design feature. The first two strategies overlap somewhat because some options for concealing solar energy systems and solar building features can also be used to integrate them.

In presenting these alternatives, it is not the intention of this guidebook to determine what is good design for solar buildings and energy systems. The acceptability of any solar building depends on its design and style, the design and placement of the solar energy system, and the appearance of the building in the context of its immediate surroundings. This manual only suggests alternative ways to achieve a particular design objective in using solar energy systems. The architect, owner, or builder can choose among these alternatives and adapt them to his or her own tastes, the client's tastes, and the design goals of community. The end product should be a building that is pleasing to look at, compatible with its neighbors, and energy efficient.

So far, many buildings that use solar energy have been located in rural or suburban settings, with little consideration given to buildings around them. More and more solar development, though, will occur in denser, suburban and urban settings, and as infill in urban areas. Soon, there will be a need to consider solar buildings in the context of other non-solar buildings—a problem that has not really arisen in the past.

The recommendations in this guidebook are, to some degree, the result of hypotheses. Not many solar buildings are currently located in dense areas where their appearance may contrast with existing buildings. Morever, the majority of pictures or photographs of solar buildings show only the individual structures, removed from the context of neighboring development. To provide some guidance, the following material describes situations that are likely to occur, and offers some general suggestions about how solar systems and buildings can be treated to minimize potential problems in design review.

Concealing Solar Collectors or Solar Features

Although most solar installations probably will not raise design issues, occasionally it may be necessary to conceal solar collectors or the solar features of buildings from view as much as possible. In some design review districts, the residents may have particularly strong feelings that a visible collector would detract from the neighborhood and in historic districts, visible collectors may be considered to present too radical an appearance. Although visible solar collectors have been installed on historic buildings with the approval of the National Register of Historic Places, complete concealment may be appropriate on some individual buildings when it is felt that an historic architectural style is not compatible with visible collectors.

Design strategies to conceal solar installations have some limitations, however. All of the techniques discussed below rely on the concept of "sight lines"—minimizing the visibility of the equipment from the perspective of a pedestrian or motorist viewing a building from a street or public area. Many of the concealment strategies will not conceal the solar equipment from the view of adjacent neighbors, who will have to live with the appearance of the installation, nor from the view of people who live in buildings that overlook the solar building. In considering these strategies, design review boards must realize that concealment only means public concealment and not total invisibility of a solar installation from all perspectives outside of a lot. These strategies are "public strategies," that can be used to affect the appearance of a streetscape, as viewed from ground level.

Roof and Building Orientation

Solar features or equipment can be designed or mounted in such a way that they would not be visible from a street or public place. Solar buildings on the south sides of east/west streets would have solar collectors facing their own backyards and may not look like "solar buildings" when viewed from the roadway. (See Figure 25.) This means that only the buildings on the north sides of the streets would have solar features facing the road. This orientation suggests that solar design may not even be an issue for at least half of the buildings fronting on east/west streets. But the unusual appearance of north walls having few or no windows may raise different design problems; these issues are discussed in greater detail later in this chapter.

For buildings on north/south streets, the collector array or roof-mounted skylight can be concealed by designing a roof with an east/west peak. Because passive, wall-mounted glazing will be difficult to use in most situations of relatively high housing densities, roof orientation is important. This type of solar installation may be less visible from the front of the house, where the design of the building allows the use of a peaked roof facing south, or where an existing building with such a roof is to be retrofitted for solar energy. Figure 26 shows collectors mounted on the south roof surface of the building in the center. This installation might be most appropriate when neighboring buildings also have peaks running in a similar direction.

Parapets

Collectors can be hidden from view by the use of parapets, provided that parapets are appropriate for the building's style. A flat roof and an architectural style which traditionally uses a parapet around a flat roof surface, are important design considerations for using this approach. Mansard-type roof shapes can be modified in some cases to

Figure 25 Concealment by Building Orientation

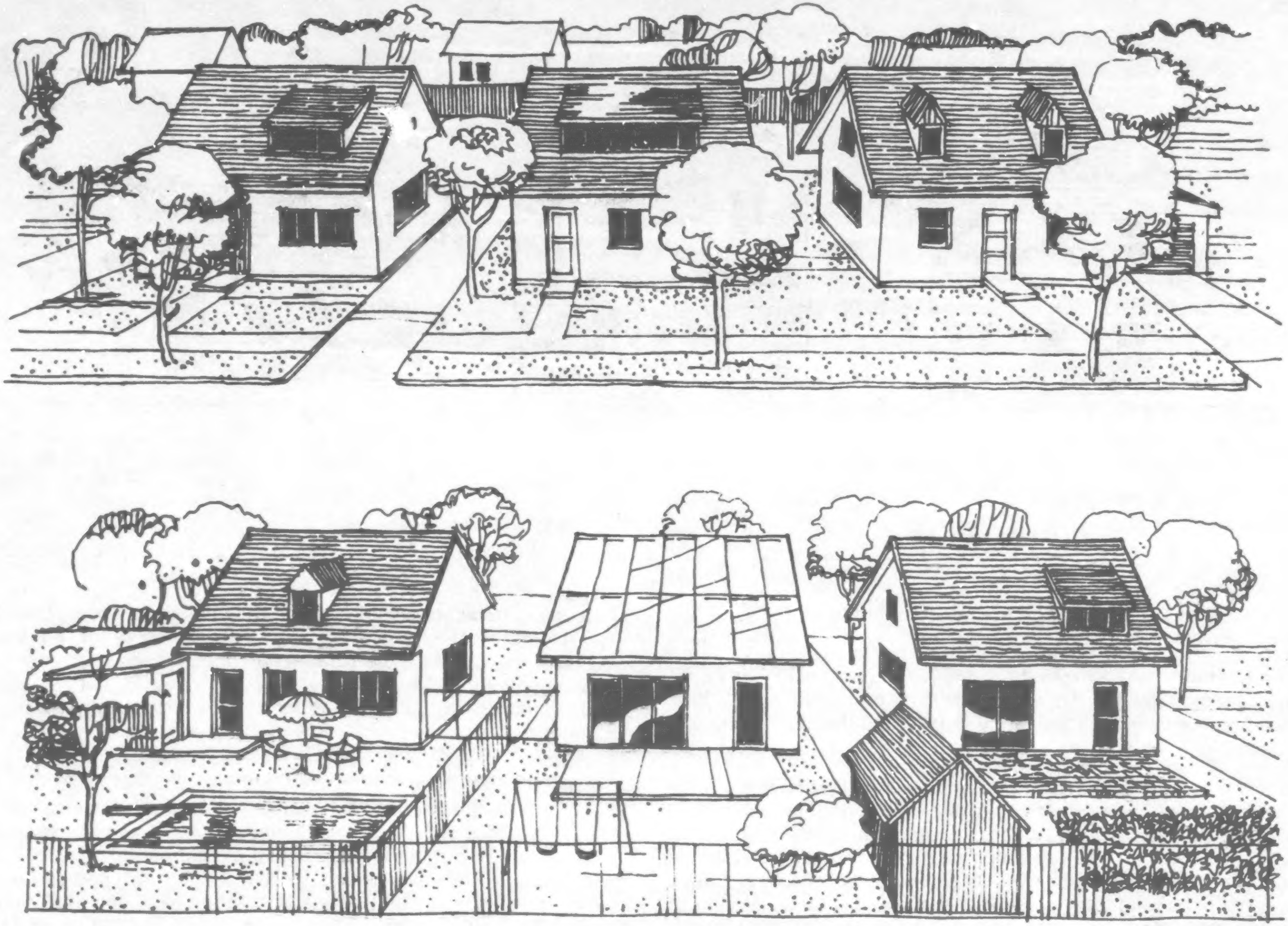
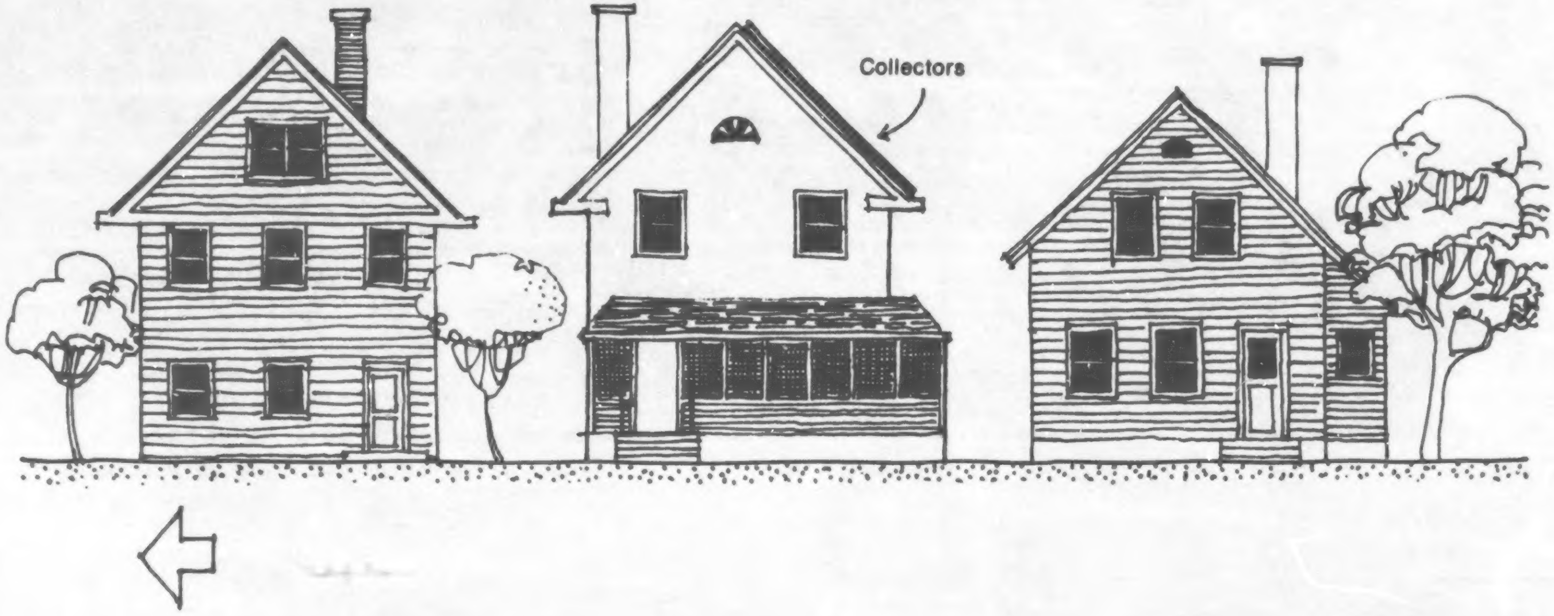


Figure 26 Concealment by Roof Orientation



form a parapet around a flat center section of the roof for some modern housing designs.

Figure 27 shows how a parapet can be used to conceal an array of active collectors mounted on a flat roof. The ground-level view shows that the collectors are rarely visible, and the parapet complements the building's style.

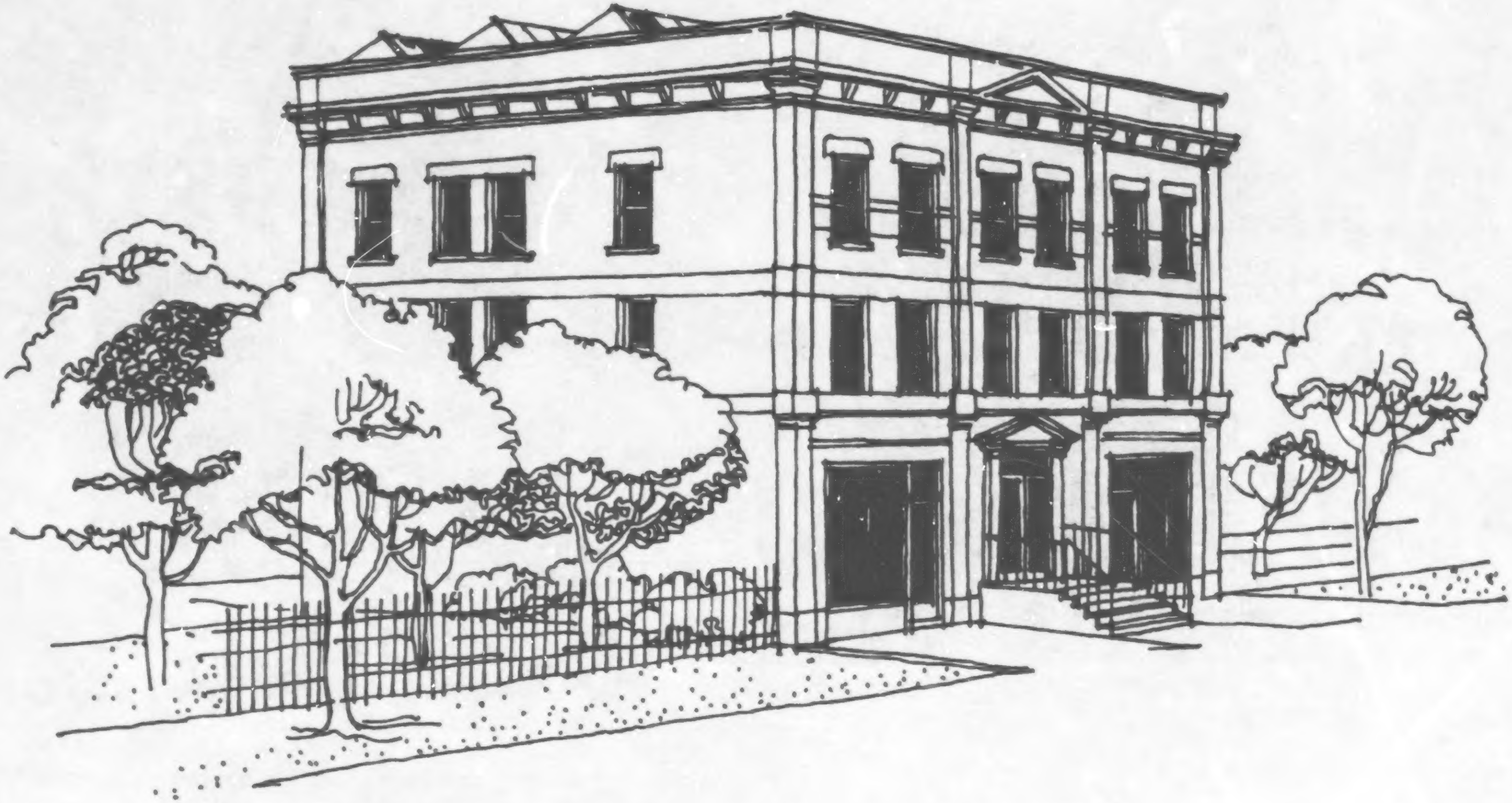
Parapets may be most useful in historic districts that have many flat-roofed buildings. The front of an historic townhouse, for example, could be fitted with a small parapet to conceal an array of collectors mounted on the roof. The design of the parapet should be historically appropriate and should not raise the roofline of the townhouse above that of its neighbors. It is likely that such an installation would be almost invisible from street level, but parapets will not conceal collectors from the view of people in adjacent taller buildings.

The use of parapets as screening devices must be approached carefully so that solar access is not affected and also so that the building does not look as if the parapet has been tacked on merely to hide something on the roof. One further concern is that parapet walls, unless carefully designed for adequate roof drainage, are notorious for causing problems with roof leaks.

Setting Collectors Back from Sight Lines

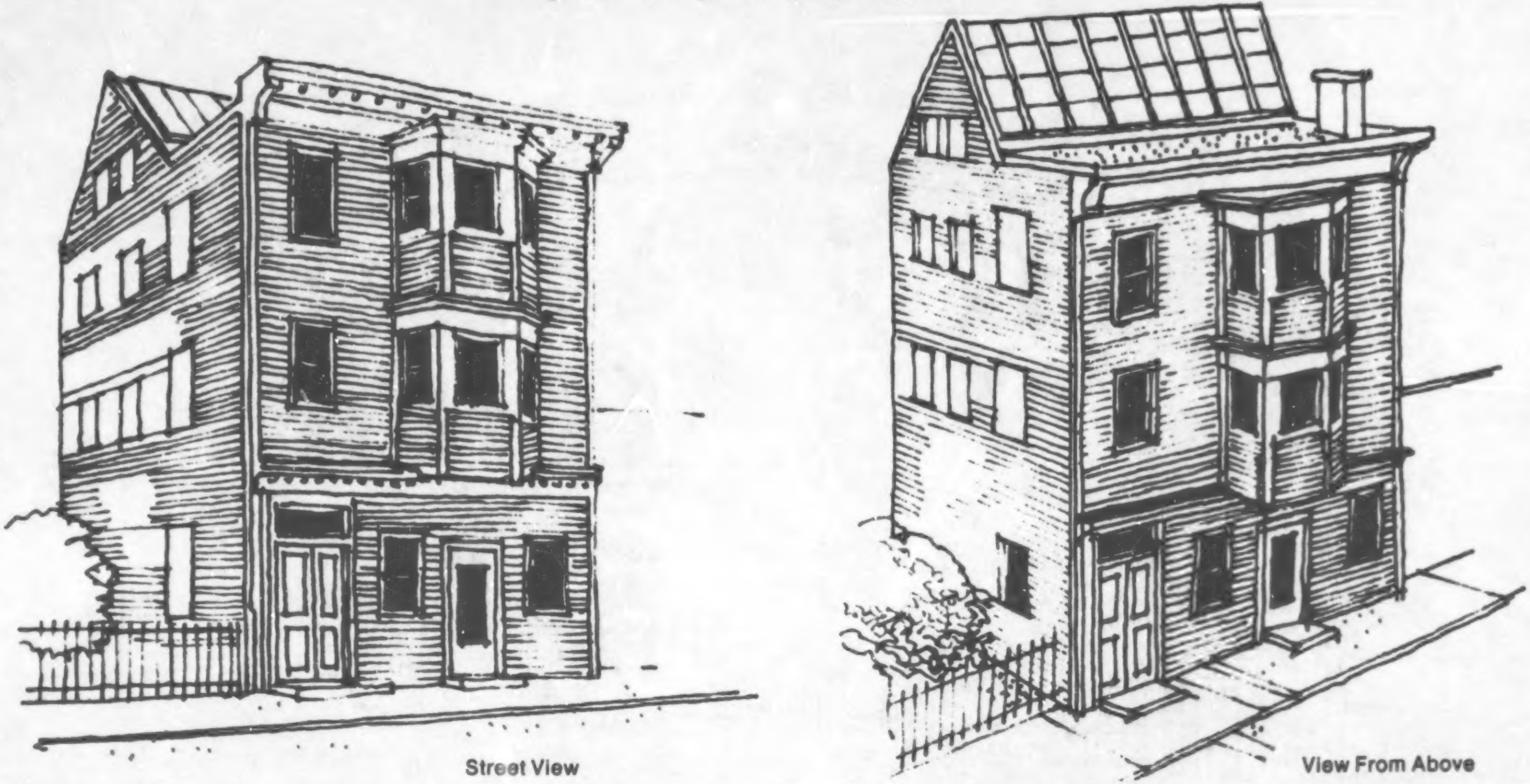
Rooftop collectors may be concealed by locating them near the back of the roof of tall buildings with flat roofs. This way, the collectors are further out of the sight line of people on the ground. Figure 28 shows a sketch of an actual building with a retrofitted active collector installation. By moving the installation back, the designer concealed it from view at street level. In this case, the projecting cornicework also helps to conceal the collector.

Figure 27 Concealment by Parapets



The effectiveness of this technique depends on the size of the roof and the height of the building. The taller the building, the easier it is to hide rooftop collectors from view. Also, a building that is longer from front to back makes it possible to locate collectors further away from the sidewalk and street side of the building. If the building is open to view from tall buildings nearby, the collectors will be visible despite their recessed location.

Figure 28 Setting Back Rooftop Collectors



Street View

View From Above

Landscaping and Fencing

Landscaping can be used to conceal a collector or integrate a solar building into its surroundings. Ground-mounted active collectors can be completely concealed by proper placement of low shrubs. This strategy is especially effective when the collector is visible from the street, but care must be taken not to decrease the amount of sunlight falling on the collector.

When solar collectors are placed on the rooftops of low buildings surrounded by high rises, landscaping can be used to create a more pleasing appearance. This is a traditional method of improving the appearance of rooftops covered with a great deal of mechanical equipment, and the technique is just as useful for integrating solar collectors. (See Figure 29.) Again, solar access is an important consideration in locating the vegetation.

Landscaping can also be used to conceal or integrate the solar features of detached and multifamily housing. A building can be partially screened from public view by fencing, hedges, or other landscaping materials if its design is radically different from (or conflicts with) the appearance of neighboring buildings. But the screening should maintain the character and landscaping features of the rest of the neighborhood.

Figure 29 Landscaping Used with Rooftop Collectors

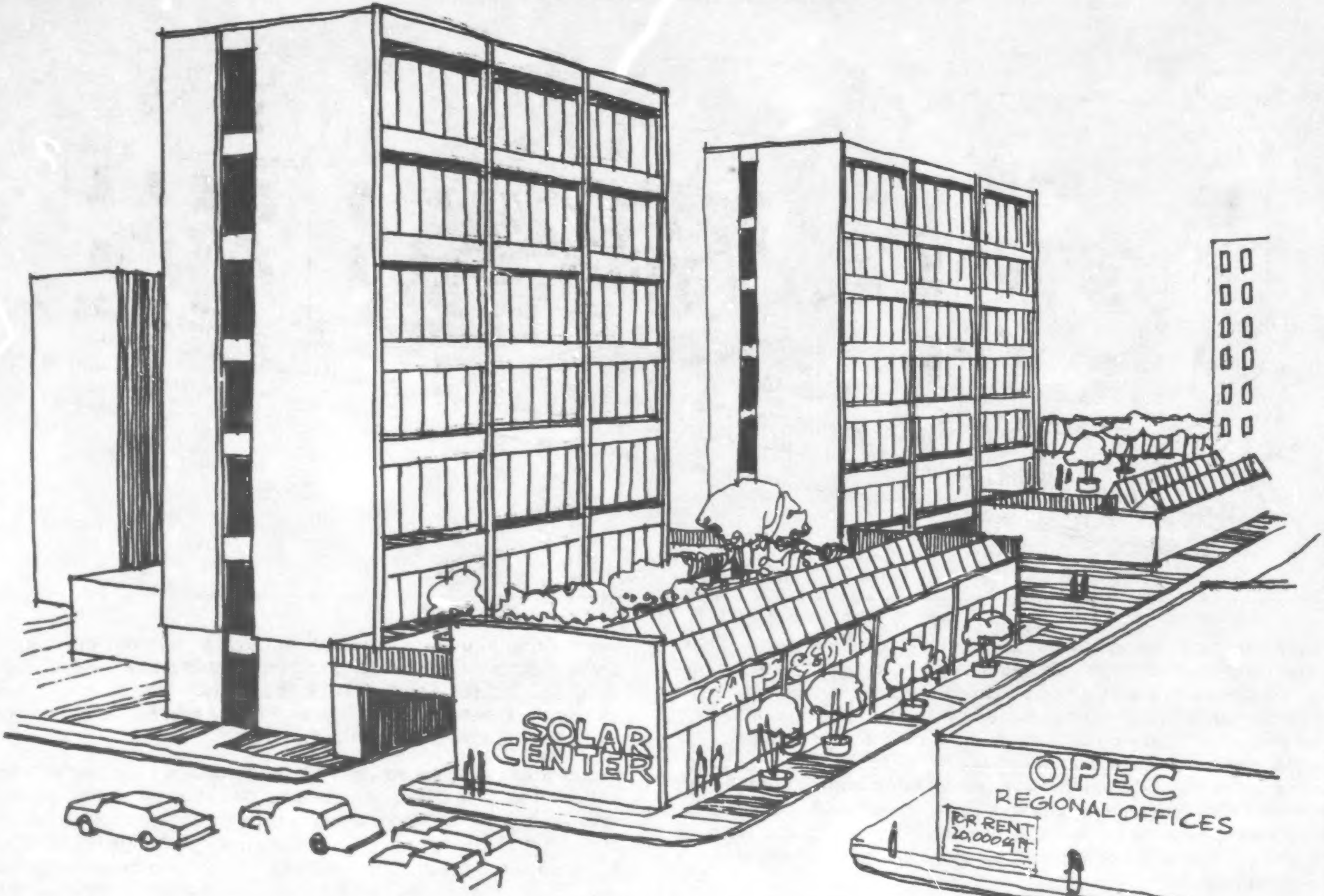
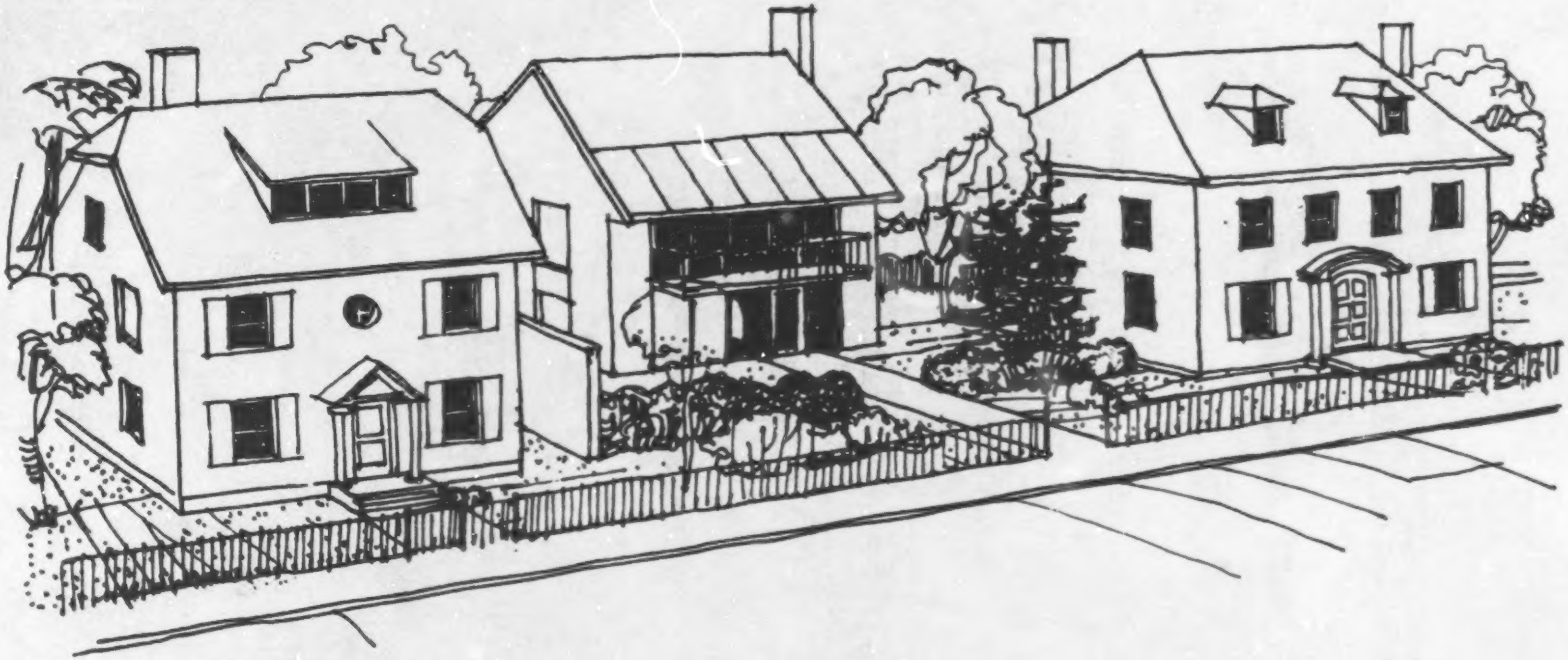

SOLAR
CENTER
OPEC
REGIONAL OFFICES
FOR RENT
20,000 sq ft

Figure 30 Solar Buildings Set Off with Landscaping

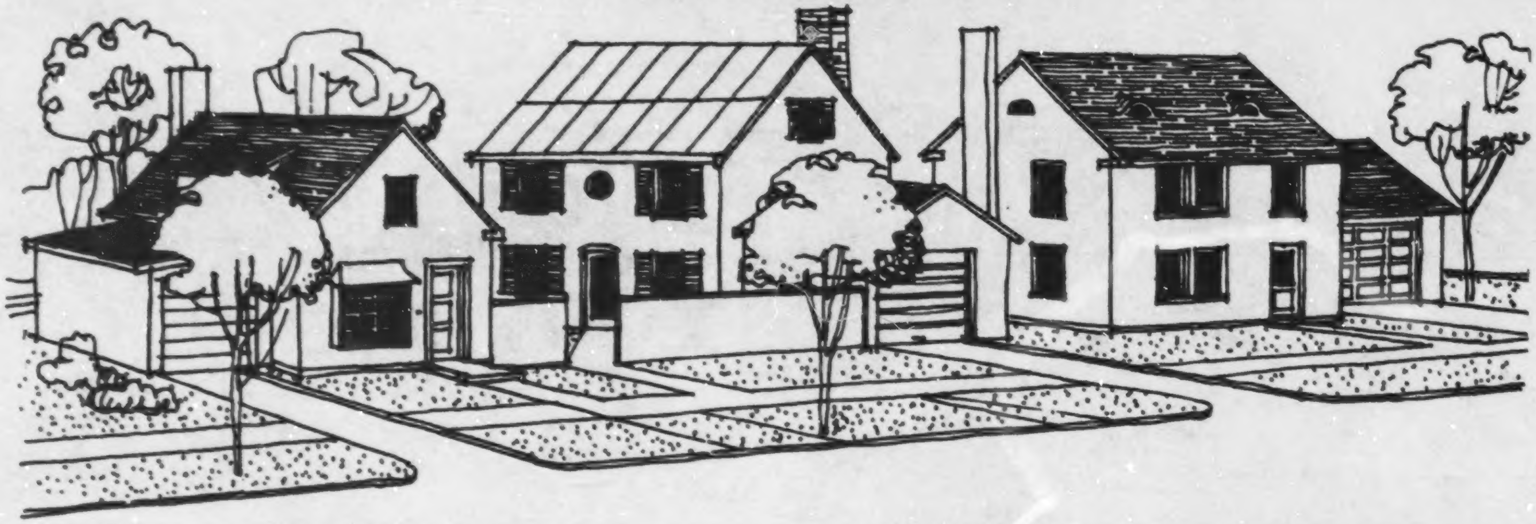


Landscaping can be used when a solar building is sited farther back on its lot to conceal solar features or equipment, but this technique may be appropriate only when buildings are sited in this manner; when the building will not be shaded by nearby buildings or trees; and where local zoning regulations allow such siting flexibility. Landscaping materials, such as shrubbery or fencing, can be used to maintain continuity with the features of other homes in the neighborhood. While the uneven setback isolates the building somewhat from the appearance of its neighbors, the landscaping and the building design help to make the building more compatible with the neighborhood.

Figure 30 shows an example of this strategy. The fencing across the front of the lot with the solar building is the same as adjacent lots, while the low shrubbery lines up with the building setback lines of neighboring structures. The wall and evergreen trees provide privacy. Both the landscaping and building must be carefully sited to avoid shading solar collectors. This approach also adds visual diversity to the appearance of the street, relieving a sense of monotony that can result from uniform setbacks.

Landscaping and fences can be used to partially conceal or integrate the solar features of a building that must be shifted on its lot in order to avoid collector shading or to provide optimal solar orientation. Fencing, hedges, or accessory buildings (such as garages) can provide continuity with neighboring development and setback lines, and they can also help conceal solar features of the building that are thought to be incompatible with local design objectives or neighborhood character. Figure 31 illustrates this design strategy.

Figure 31 A Solar Building Shifted on Its Lot



As a last resort, landscaping can be used to completely conceal a solar building when its design is considered totally out of place in a neighborhood. A very modern and industrial-looking solar building with visible tracking collectors proposed in an historic district, for example, would directly conflict with the style of its neighborhood. Dense landscaping, or high, visually impermeable fencing might be considered to screen the building from the street.

However, buildings should be totally concealed with great care and only when absolutely necessary. Designers and homeowners typically want their buildings to be visible from the street, and extensive, dense landscaping may draw even more attention to the lot than if the building or equipment were left visible. Whenever possible, a modification in the building design is preferable to extensive screening.

Berming

Ground-mounted solar collectors can be concealed or integrated through the use of earth berming—building up earth around the collector. Berming, as opposed to using a separate collector mounting, makes the appearance of the collector less obtrusive. Figure 24 illustrates this technique.

Berms can also be used to obstruct a person's view of a ground-mounted or wall-mounted collectors. A berm can be built between a roadway or walkway and the front of the solar building to hide the solar installation yet leave the rest of the building visible. This technique is common, and in conventional development berms are often used to vary the topography of a site or to modify drainage patterns on a lot. Figure 32 shows how berms can block the view of the solar features of the building.

The use of berming is, of course, limited by the character and topography of the site and its neighborhood. If the surrounding area is fairly densely developed, then berming may not be appropriate. A berm may look inappropriate on a flat site or may not conceal effectively. If lots are not large enough, berms can cause drainage problems on adjacent lots. They are most appropriate for large lot sites with a diverse or rolling natural terrain.

Using Building Features to Conceal Passive DHW Systems

Some passive hot water systems (thermosyphon systems) require that the water tank be placed at a point above the solar collector. This system presents an obvious problem—a highly visible piece of mechanical equipment may have to be placed on the roof. Cupolas,

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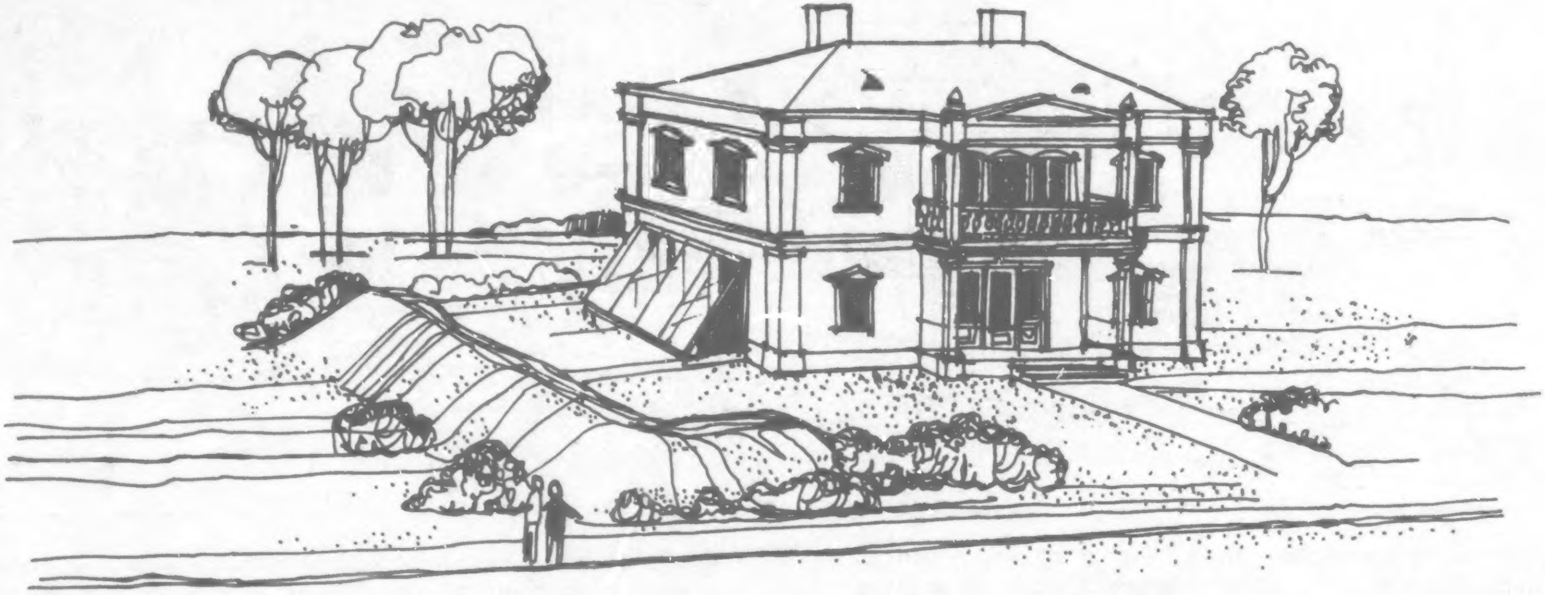
Figure 32 Berming to Conceal Solar Features



dormers, or false chimneys could be used to conceal thermosyphon storage tanks. Figure 33 shows how a false cupola is used to hide the storage tank. This may be necessary only when the collectors must be located on or near the roof peak, so that there is not enough room under the roof to place the elevated storage tank. False structures or other screening must be designed to look like an integral part of the design of the entire building.

Integrating Active Collectors into Buildings

There are three basic ways to integrate active collectors into buildings. First, when the collector array will cover only a part of a wall or roof, the collectors can be accented or emphasized as a distinct building feature. Second, when the collector array is large enough to cover an entire roof or wall, the array is treated as if it were the roof or wall surface—using it as an unconventional roofing or facing material. Finally, whether the collector array covers all or part of a roof or wall, it can be used in relation to other building features. The collector can highlight those features (like the vertical or horizontal lines of windows), or those features can draw attention away from the collector installation.

Emphasizing the Collector Array as a Design Feature

As noted earlier, active collector arrays can be mounted flush with a roof surface or raised above it Where appropriate, raising the collectors above the roof plane can accentuate the collector array and draw a sharp distinction between the collector edges, material and surface appearance, and the texture and level of the roof. Raising collectors that cover only a part of the roof surface and boxing in piping or ductwork can improve a building's appearance by accentuating the collector array as a distinct design element.

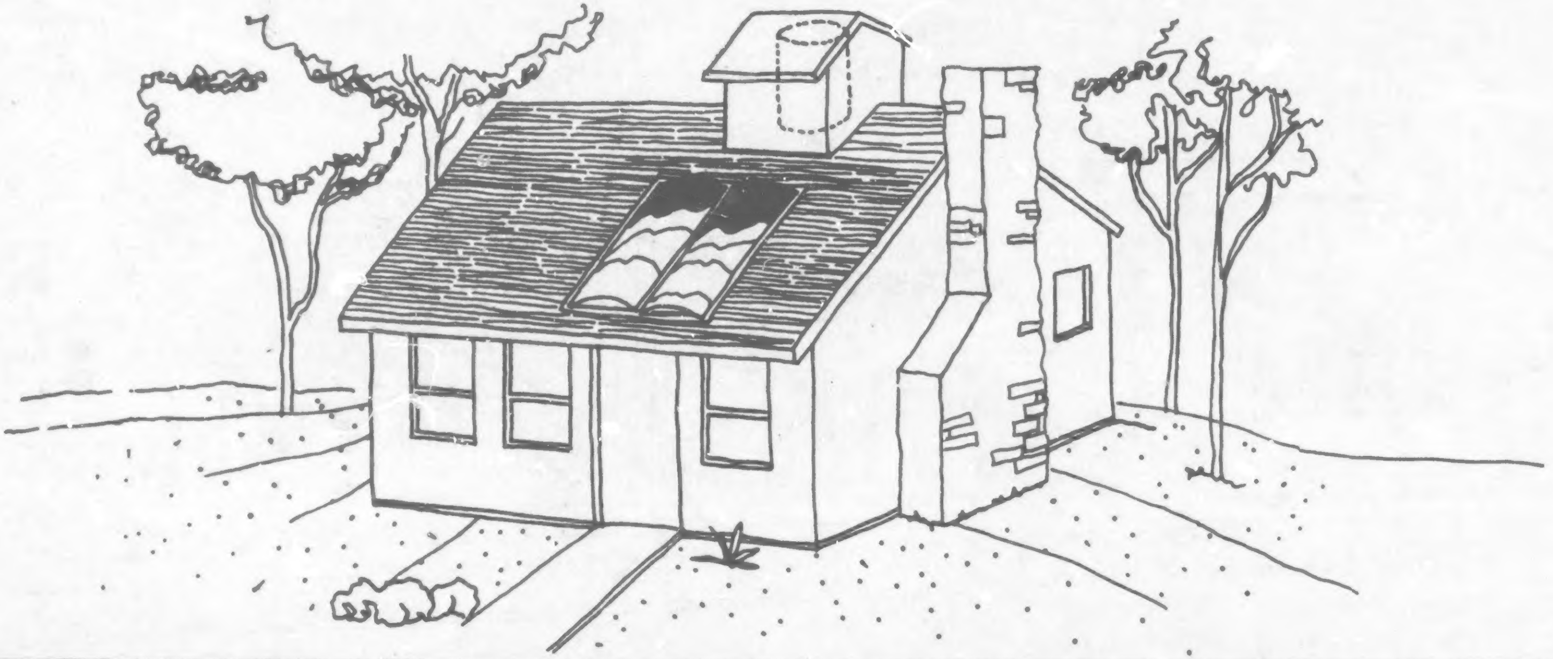
Setting off collectors from the roof is particularly useful when a collector is retrofitted and installed on a separate mounting to tilt it properly towards the sun. Although there is some flexibility in tilting collectors towards the sun (because collector efficiency will not be impaired if the array is off-tilt by a few degrees), many retrofitted installations use collector arrays mounted on racks to provide optimal solar orientation. When these racks are used and when the entire installation would be visible from the street, only mountings with paneled sides should be used. When the industrial or technical style of the building is appropriate, the use of open-frame mountings, which have a more complex appearance, can be justified. On taller buildings, where the entire assembly would not necessarily be visible from street level, the industrial appearance of open-frame mountings may not present a problem.

When the required collector array is large but does not occupy all of the south-facing roof area, special consideration must be given to the collector array's location within the roof area and its relation to the appearance of the building as a whole. As is often the case with active solar energy systems used for domestic water heating on single-family detached houses, the 60 to 80 square feet of collector area can take up a significant part of a building's south-facing roof area.

One approach is to locate the collector array close to an edge of the roof. The collector array can be arranged so that it extends along the roof eave or peak, or along one side of the roof. The rectangular collectors can be installed in the array so that their longer sides run horizontally or vertically to reinforce elements of the building's design.

Generally, it is most efficient to mount the array along the roof peak, so that the collectors are elevated as high as possible and problems with shading are reduced. However, for taller buildings or structures with dramatic roof treatment, mounting collectors near the eave may be less obtrusive. Finally, the entire array can be

Figure 33 A False Structure Concealing Solar Components



grouped vertically or horizontally—from the peak to the eave or from side to side—to reinforce elements of the building or roof design and integrate it more effectively. Figure 34 shows examples of all three installation treatments.

For retrofit installations of active solar water heating systems, this strategy must be used carefully. When a retrofitted array is located near a roof peak, it is important that the collector, when elevated on its mounting, does not break the roof line. In this situation, it is better to mount the collectors slightly below the roof peak, so that the top of the array appears to be even with the roof line when viewed from ground level.

Covering an Entire Building Surface with a Collector Array

The second strategy for integrating active collectors is to cover the entire wall, roof, or section of a building with the collector array. This approach may be most useful for large, space-conditioning installations, where the area of the collector array is as large as the building's south-facing wall or roof.

The purpose of this approach is to minimize the contrasts between the collectors and the surrounding building surfaces. For example, if the collector array covers almost all of the roof of a building, then the entire roof surface will look like the collector glazing; there will be fewer contrasts between the materials, colors, and textures of the collectors and the roofing. Figure 35 shows a building whose entire south roof is covered by a collector array.

If the collector array is not extensive, sections of the building can be designed so that the collector array will cover almost all of the mounting surface. The use of domestic hot water systems on single-family, detached housing is an example of this situation. Although the array may cover a significant portion of a building's roof area, only specially designed roofs are likely to be entirely covered by an array. If a building is to have several sections or wings, the collector array can be designed to completely cover the south-facing roof of only one section. Figure 36 shows a building with collectors installed on the roof of only one of several building sections. This design minimizes the contrasts of material and color that would otherwise result from locating the same collector array

Figure 34 Active Collectors Installed Along Roof Edges

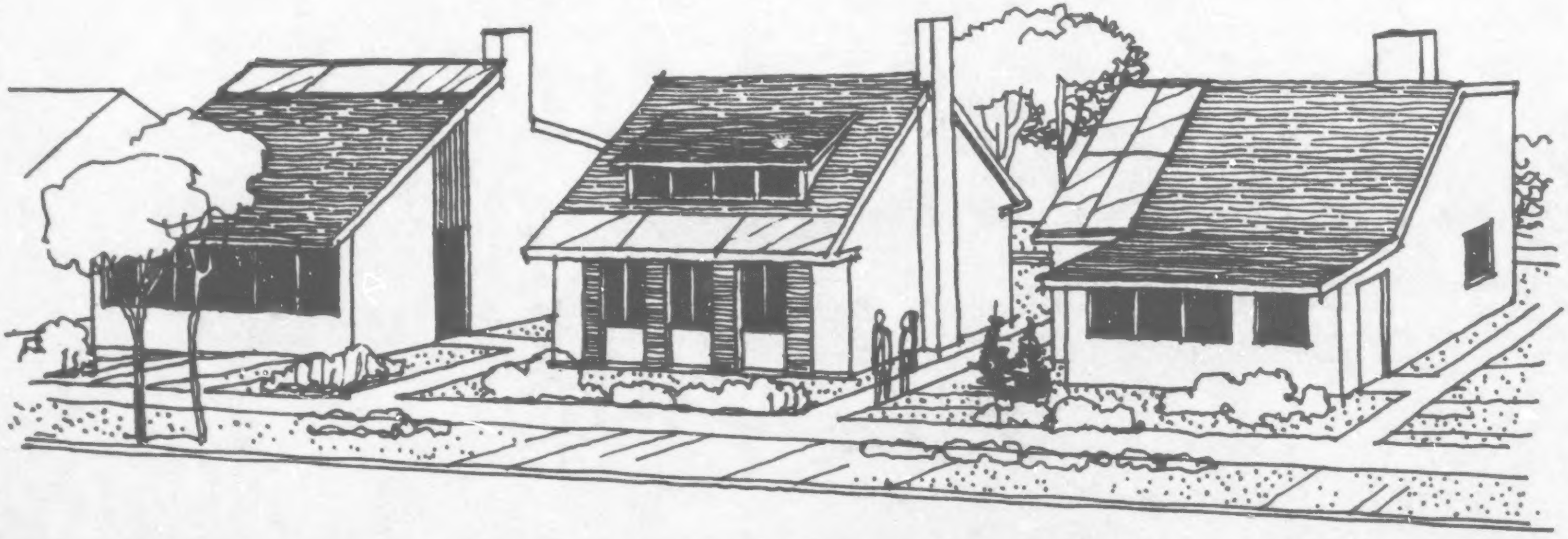


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Figure 35 A Collector Array Covering an Entire Roof

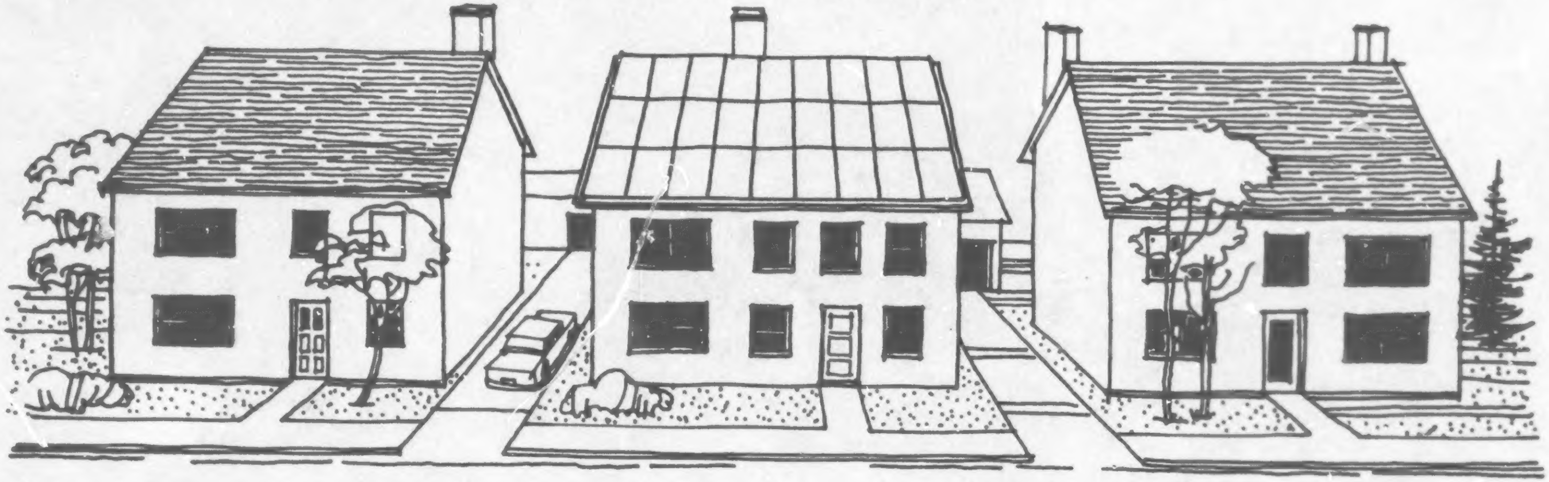

Figure 36 Isolating Rooftop Collectors

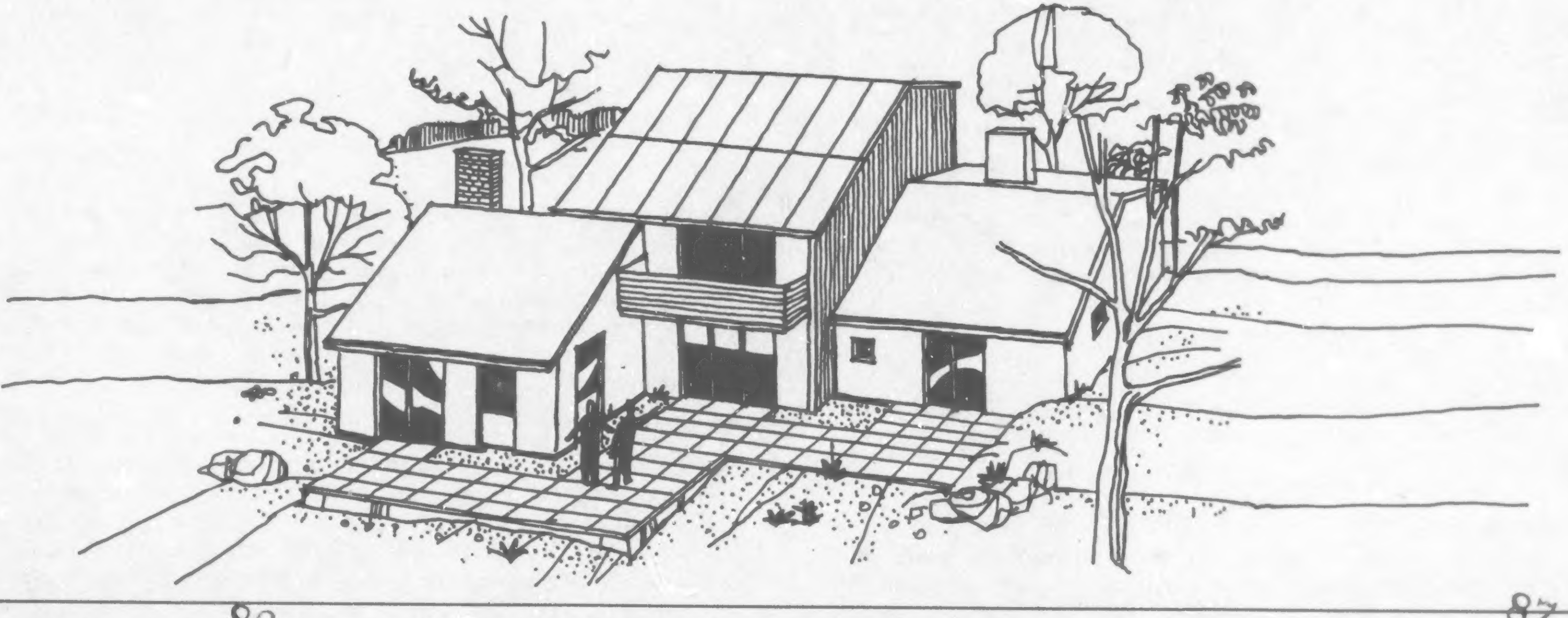

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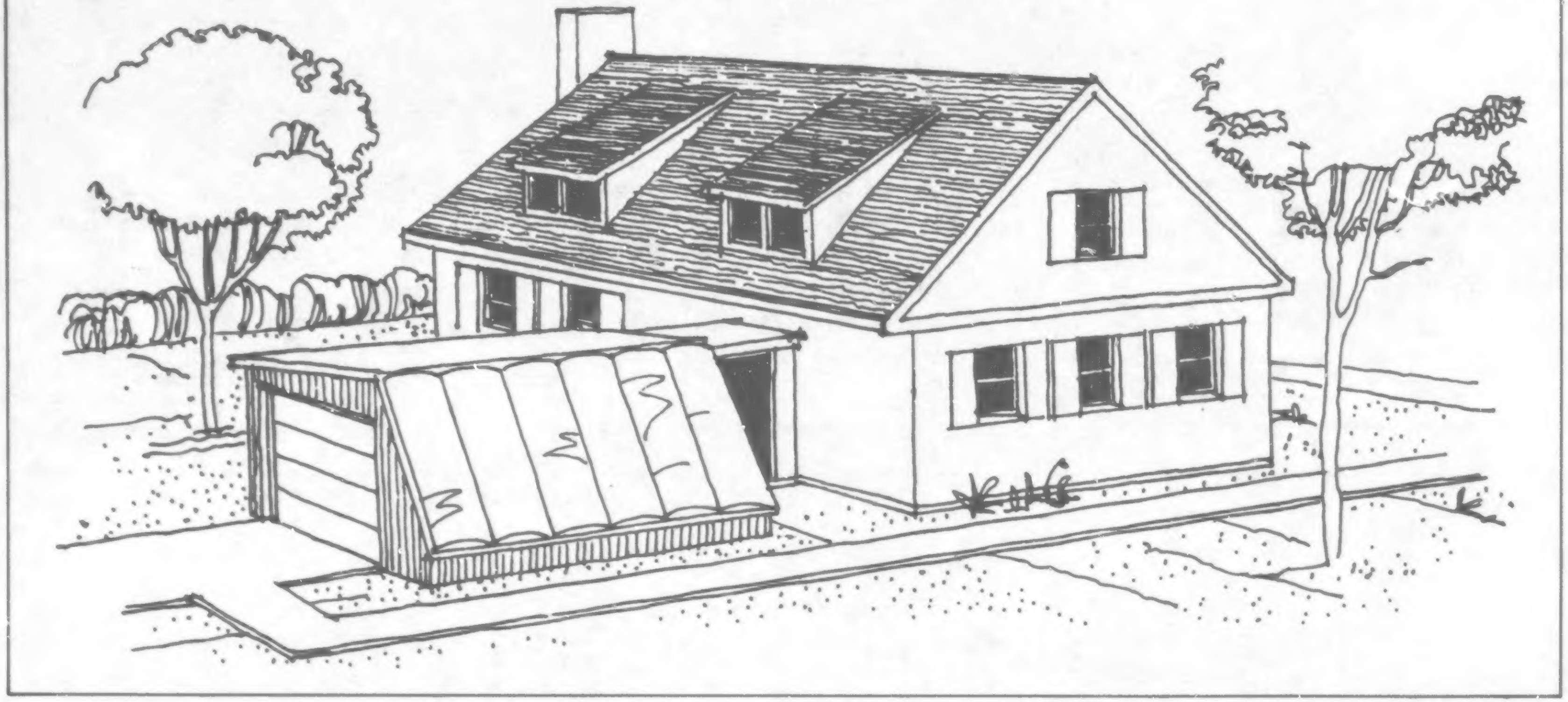
Figure 37 Isolating Curved Collector Arrays



on a single and continuous roof. It should be noted that the exposed wall and roof areas of the building are quite large, increasing its heat loss. This design is not particularly energy efficient in colder climates and is most feasible only for new development. This approach may not be possible for many retrofitted installations.

When solar collectors are retrofitted, the collector array can be mounted on the smaller south-facing roof of an accessory building rather than on the roof of the principal structure. See Figure 6 and Figure 37.

Balancing Solar Installations and Building Features

The third strategy for integrating active collectors is to relate the solar installation to other features of the building and to relate the building's design to the collector array. This integration can be achieved by placing collector arrays in locations where they reinforce the building's features; designing building features to draw attention away from or compensate for the solar installation; and installing the collector array in such a way so that it balances building features. These approaches can be considered whether the collector array covers all or part of a roof or wall.

The design of a building can be reinforced by the proper location of a collector array. The array can be placed so that it lines up with windows or doors of the building, enhancing the appearance of the facade and its features. For example, a collector array may be placed on a roof so that it balances the arrangement of windows and

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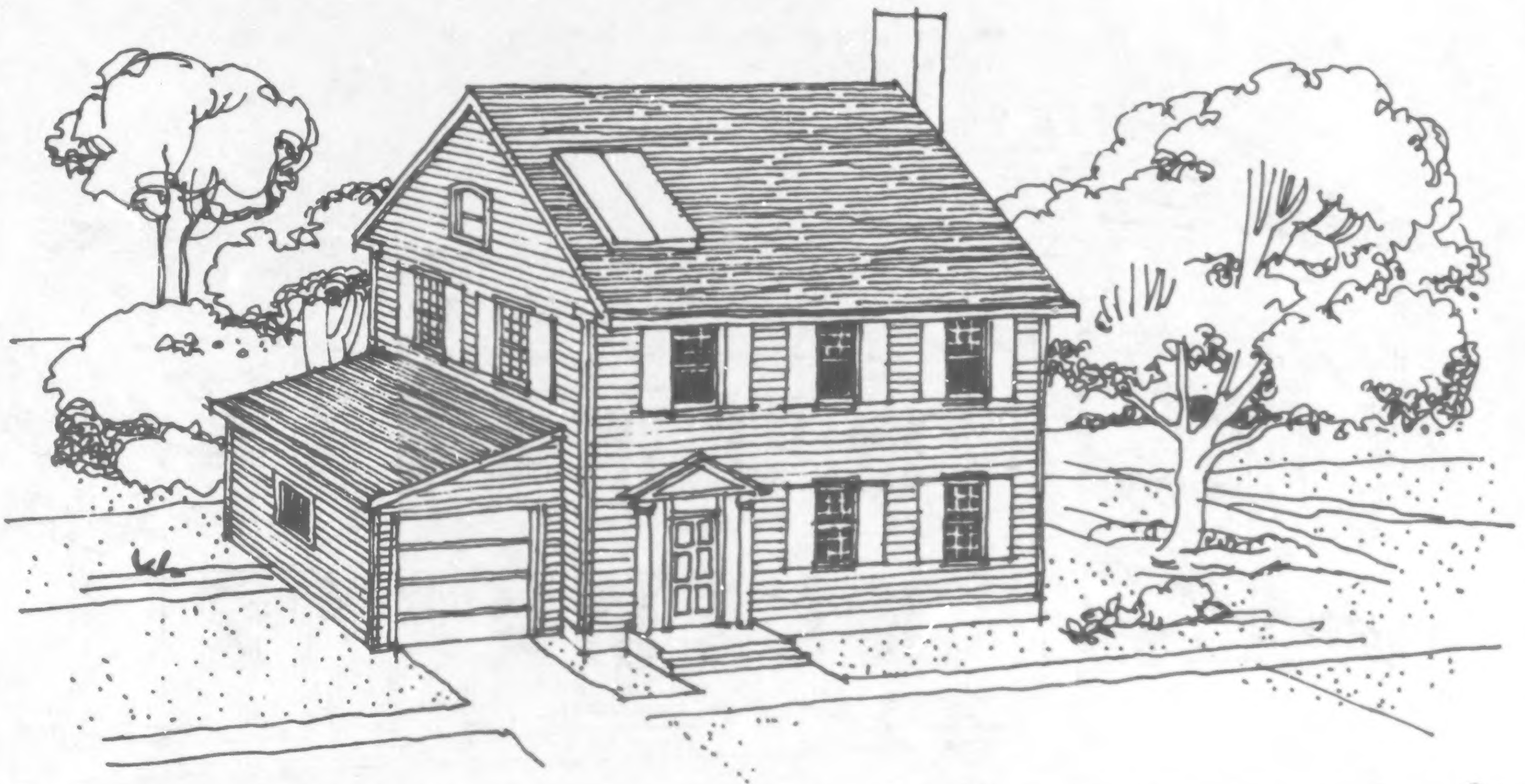
doors on the building's facade by lining up with the vertical arrangement of these features. This is shown in Figure 38.

The reinforcement approach is recommended in the Piscopo solar design manual, discussed in the next chapter. Piscopo's design guidelines are reproduced in Appendix II. They suggest that the collectors and their boxed-in piping be painted the same color as the building (or painted the color of the building's trim) and be located on a roof immediately above a line of windows or a door. Figure 38 is adapted from the manual, showing how this installation looks on a Colonial-style house.

Compensation is slightly different. Rather than locating the collectors unobtrusively, the building features are designed and accentuated to draw attention away from the collectors. The building's

Figure 38 Reinforcing Building Design on a Solar Retrofit



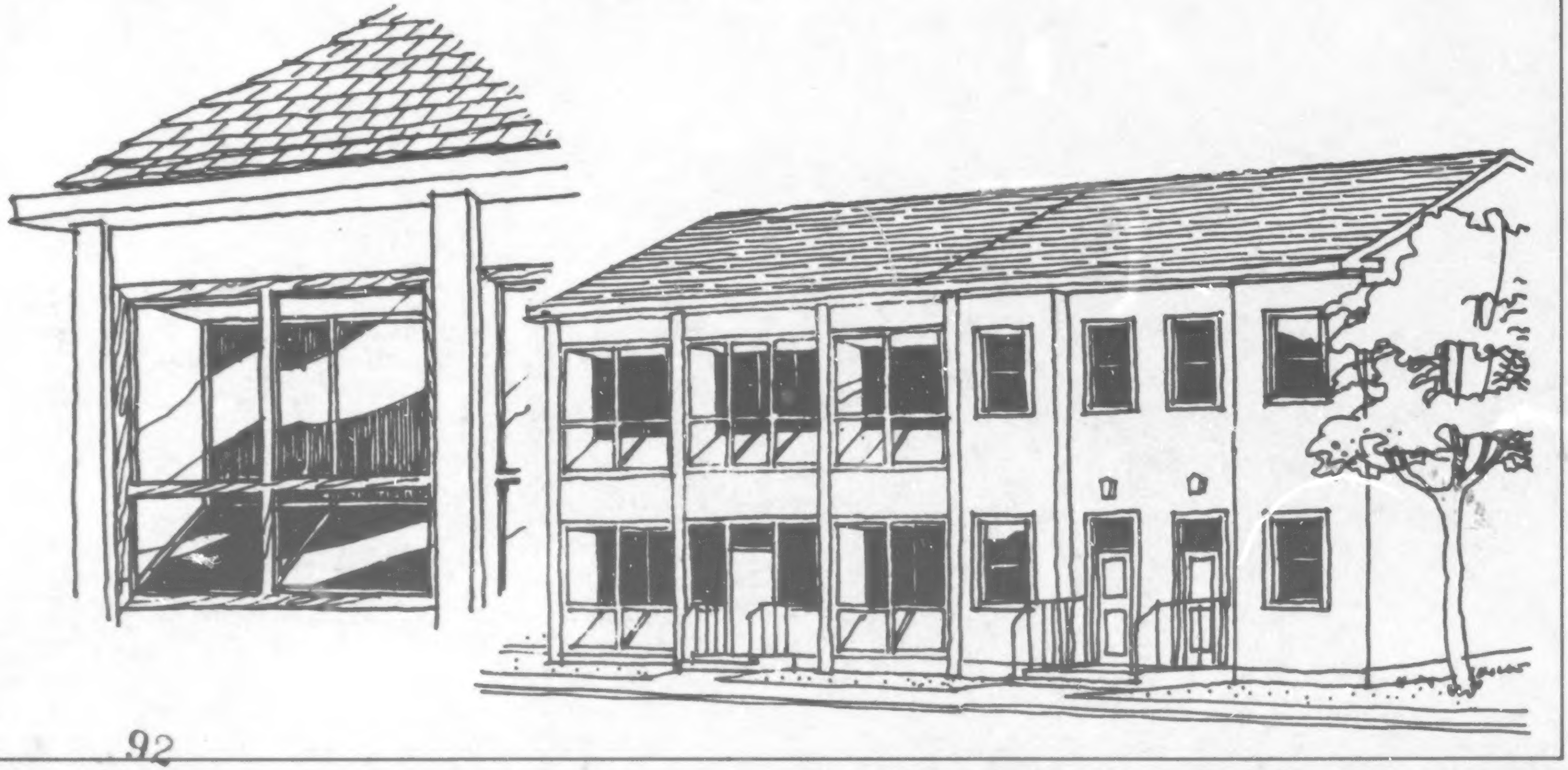
trim or detailing can be used to focus attention on them and to relate the building to neighboring structures so that the solar installation is not very apparent.

The compensation technique is used in the rowhouse example of Figure 39, where both the wall-mounted collectors and the windows are glazed as part of the facade. In this example, the collectors are tilted towards the sun and the windows are properly shaded by an overhang, while the vertical plane of the exterior wall is maintained. The glazing trim picks up the lines and window spacing of neighboring buildings and draws attention to the building facade rather than to the collectors lying at the base of the inset windows.

Collectors can be installed to balance other building features. This means locating the collector array on a building so that its mass, color, texture, and bulk harmonize with other building features. The appropiate place for the array is determined only after assessing the appearance of the solar installation and assessing, also, the appearance of prominent building features. The array is then placed so that it maintains the symmetry of the building facade.

Balance and symmetry are important issues when determining the location of collectors. Rooftop features, for example, should be scrutinized for their potential to balance or compensate the collector

Figure 39 Compensating for Solar Collectors with Building Trim and Details

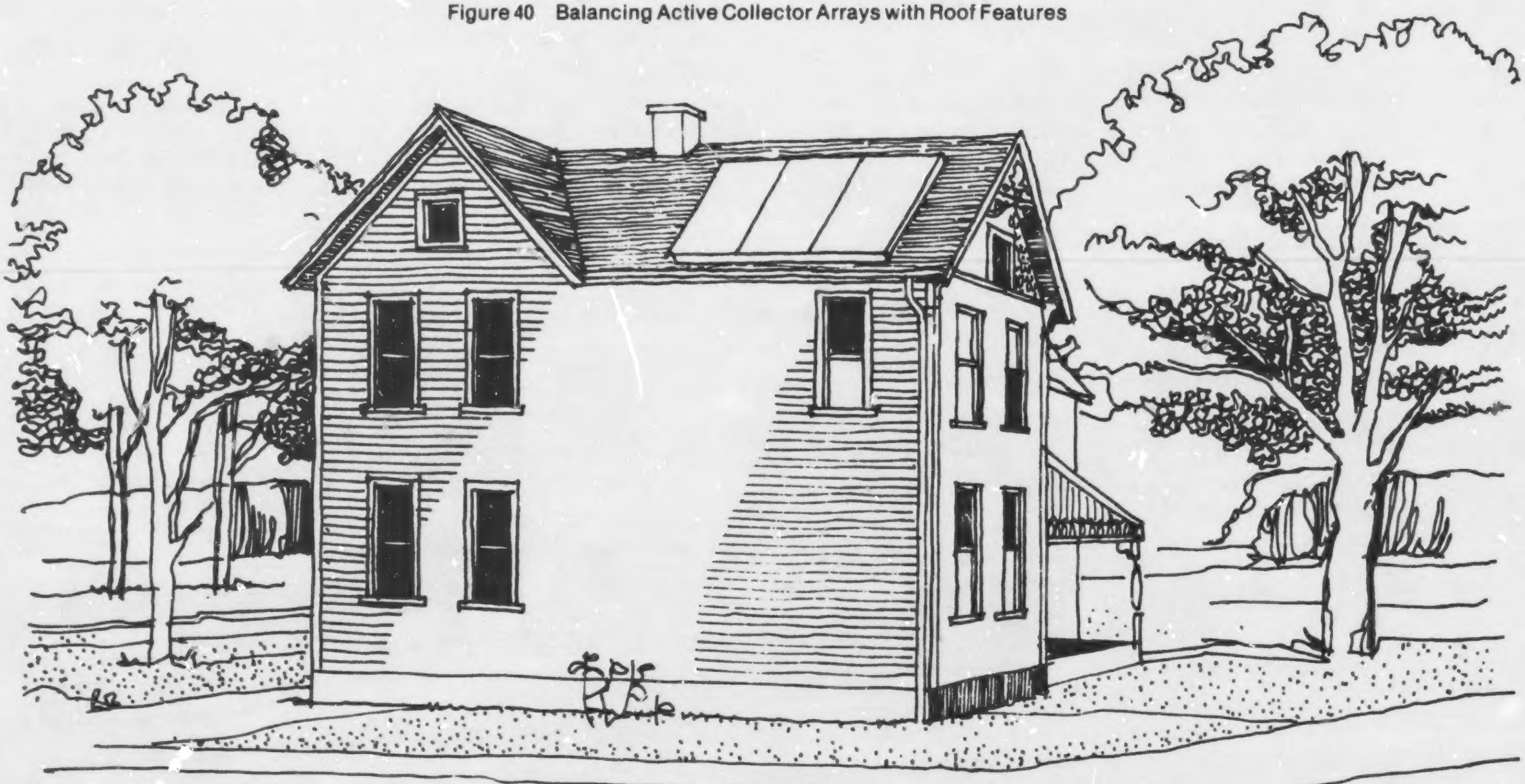


array. This attention to arrangement is similar to the idea of composing a painting or photograph.

In some cases, it may be appropriate to locate the collector array far away from some other major feature of the roof, like a dormer or chimney, in order to balance the appearance of the rooftop. In other cases, where there is a chimney or dormer at each side of the roof, centering the array can preserve the building's symmetry. Even large roof features, such as clerestories, can be used to shield a collector array from view. The solar access requirements of the collectors must be considered when locating the array near large building features that can cast shadows across them.

Figure 40 shows a collector array on an historic building in Indiana The array is located on a section of the roof facing the building's back yard and would not be visible from the street. In this example, the collector array is balanced by the raised gable; although it is not centered on the roof, it still preserves the symmetry of the facade.

Figure 40 Balancing Active Collector Arrays with Roof Features



Integrating Passive Collectors into Buildings

Passive solar collectors should be designed as an integral part of a building. In new construction, there is ample opportunity for an architect to design passive glazing, windows, skylights, and other features so that the passive solar energy system seems a part of the building. Some designers may choose to emphasize the collector as an important element of a building's design. Others may design passive glazing to look more like a conventional building feature. Design review boards concerned with the visual impact of passive collectors should be aware that flexibility is possible in the design and integration of passive collectors into new or existing buildings.

Minimizing the Prominence of Extensive Passive Glazing

Generally, a collector surface on the same plane as a building wall relates the glazing to the building better than a collector in a different plane. Tilting a collector (or greenhouse) away from the wall plane increases its visibility and can make the glazing dominate the design of the building. Other potential design strategies focus on minimizing the prominence of extensive passive glazing.

Several strategies for dividing a large expanse of glazing into smaller units can be considered. One approach is to design a building so that it uses several smaller windows rather than one large expanse of glass as a solar collector. Figure 41 shows two identical passive buildings using passive glazing; the building on the right uses several windows rather than the large expanse of glazing used by the building on the left. It is often less expensive to build a passive system with one large storage system rather than with many smaller ones located behind the smaller glazed collectors. When weighing the value of this approach for a specific project, the designer should consider cost and determine how well the building's floor plan accommodates the need to couple living space and thermal storage.

A variant of this approach is to retain the large glazed collector surface, but to break up the appearance of this expanse of glazing by the use of trim details. A large pane of glass can be divided into smaller areas by the use of mullions (the trim that frames a win-

Figure 41 Passive Glazing Arrangements

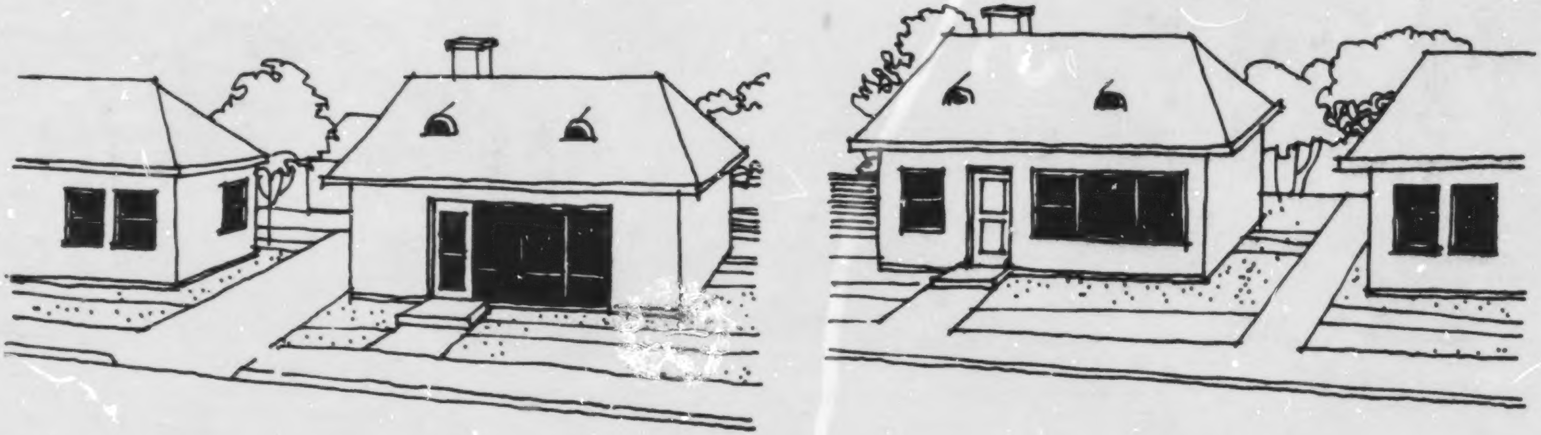


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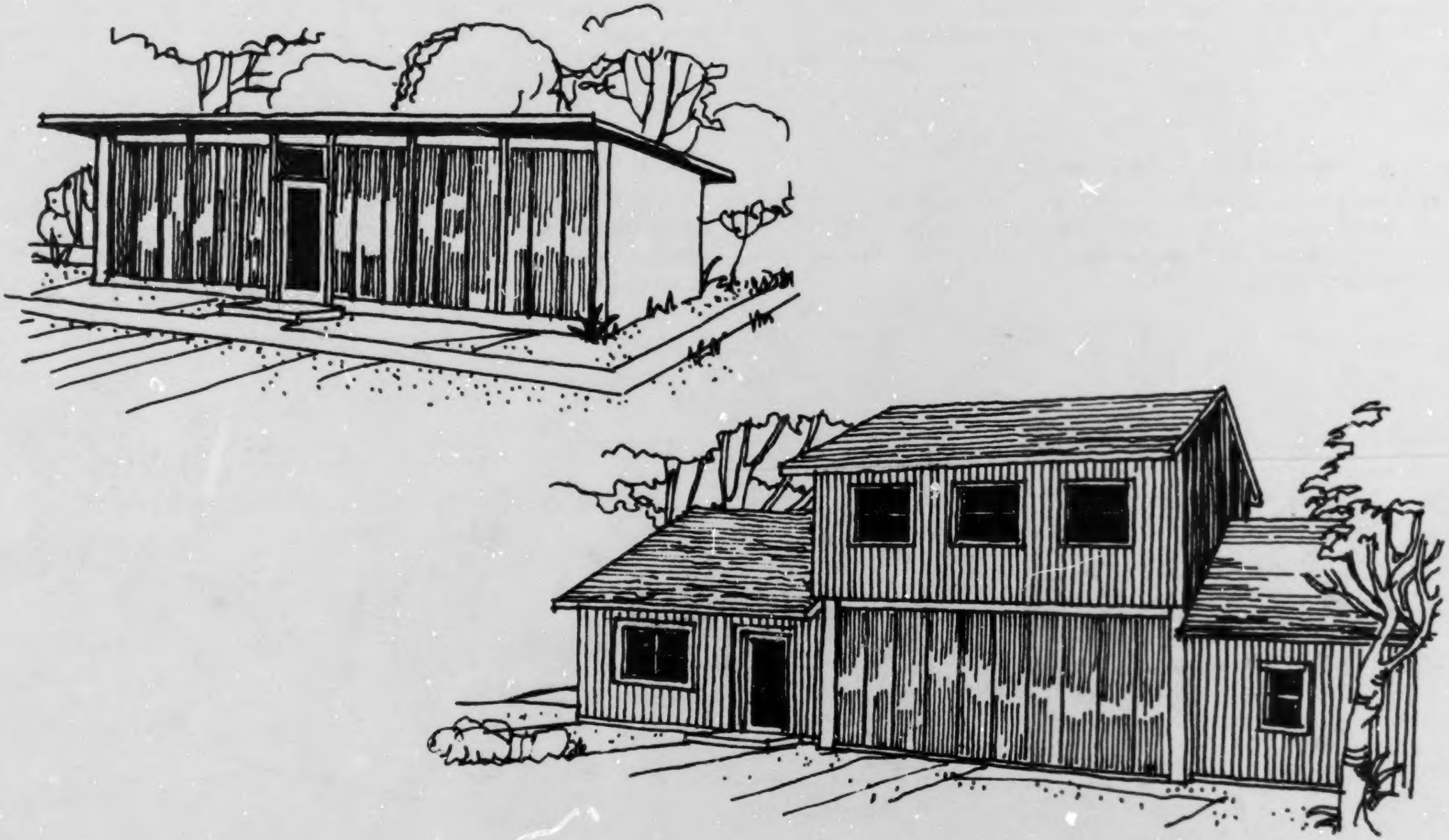
Figure 42 Unconventional Glazing Used as Design Elements



dow), so that the collector glazing reinforces the patterns of adjacent windows or building details. In an extreme case where extensive glazing might be totally inappropriate, window muntins (bars or trim supporting many smaller panes of glass) can be used, but the design must not make the solar installation look like a poorly disguised picture window totally out of proportion with the rest of the building. Extensive window trim can also block sunlight to the collector, increase costs, and create maintenance problems. The window trim can use colors or materials similar to those used elsewhere on the building, or can repeat details from adjacent buildings to establish a visual continuity.

Integrating Unconventional Glazing Materials

As discussed earlier, passive systems can use materials other than ordinary glass. Plastics or fiberglass with the proper physical characteristics can be used as glazing; they may be translucent or transparent, and corrugated or flat.

Because of the unconventional appearance of these types of glazings, it may be more difficult to integrate them into passive buildings. One approach is to pick up the characteristics of the glazing in the building's trim, or use the glazing's appearance to reinforce elements of the building's design. Figure 42 shows examples. The building on the left uses the unique appearance of translucent corrugated glazing as a design element; its texture is an important feature of the design. The building on the right uses vertical trim to draw attention away from the corrugations in the glazing material. The glazing reinforces the vertical lines of the building siding, and so is better integrated into it.

Highlighting Solar Features

The basic designs of new solar buildings, particularly buildings of contemporary design, have been derived from their use of solar energy. Large roof areas of solar collectors, greenhouses, and bold, passive glazing have been made the dominant features of many of

Figure 43 Roof Pitch Highlighting Solar Collectors

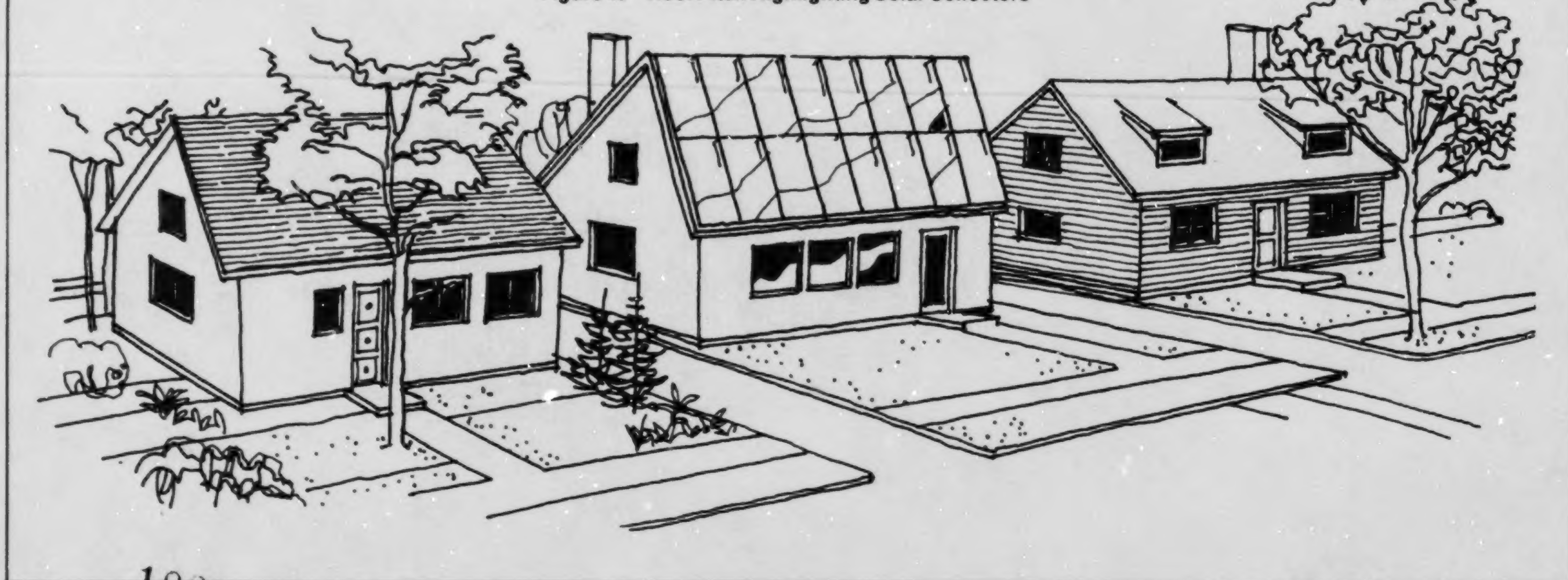


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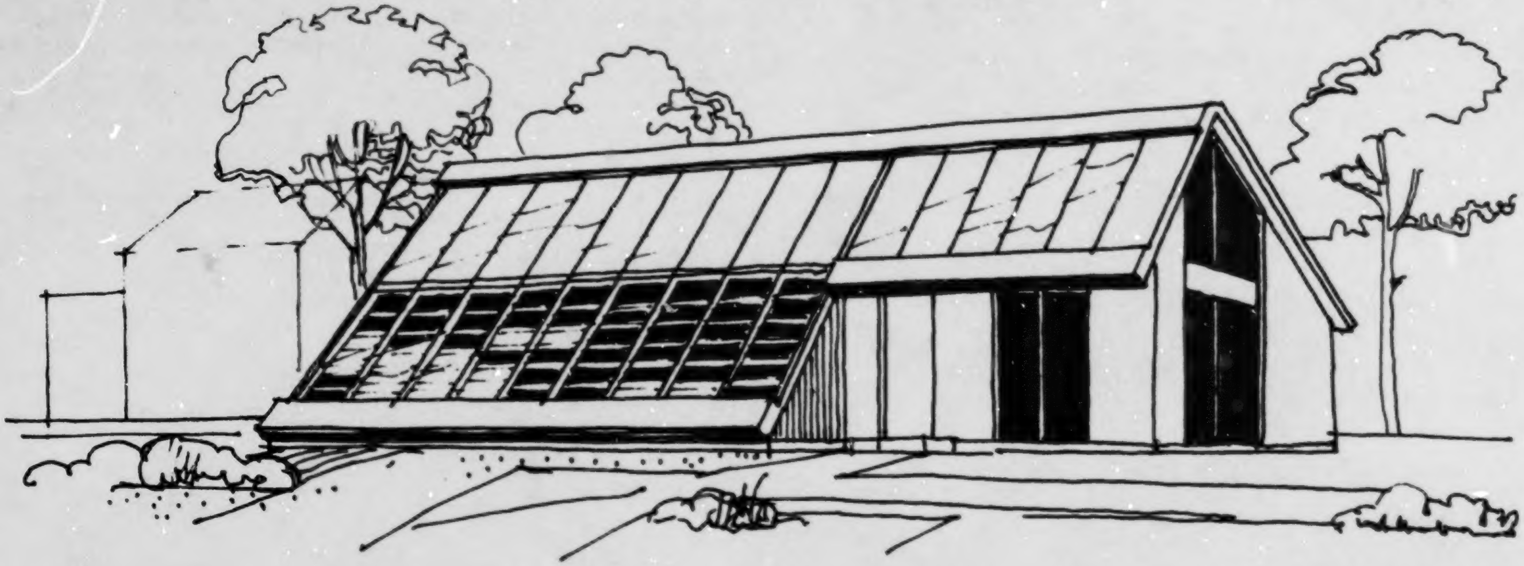
Figure 44 Roof Extension Highlighting Building Design



these buildings. It is up to a design review board to decide whether or not this treatment of solar features is desirable or appropriate in a specific location. Although dramatic design treatment for solar features might not be desired in an historic district, it could add a positive aspect of diversity to many other areas of the community.

There are many ways in which a designer may choose to highlight a solar collector as part of a building's design. As a rule-of-thumb, accentuated collectors and glazing that have an identifiable relationship to the rest of the building may be preferable to review boards than collectors that are installed without consideration to the building's total design. A visually prominent solar energy system installed on a residential building without regard to the total appearance of the structure may result in an incongruous, disjointed design—a home that looks more like a solar "machine" than a habitable dwelling. The accentuated solar features should look like part of a house, rather than the house looking like an appendage to a solar collector array.

Roof Pitch, Size, and Materials

Active roof-mounted collectors or passive collectors, such as clerestories or skylights, may be inadvertently accentuated merely because collectors must be tilted properly to receive as much sunlight as possible. The solar features of the building may be especially prominent when the building is sited in an area next to other buildings with less radical roof tilts. Figure 43 shows such a situation. Not only is the roof highlighted because of its tilt, but the collectors become more exposed to view from the street. The collector glazing (or passive glazing) is seen as the dominant roofing material (if the collector area is large) and contrasts with the roofs of adjacent buildings. Roof pitch can be more strongly emphasized to make the collector a prominent part of the building's design. The tilt and shape of the roof can be extended with a greenhouse, as in Figure 44, to become a dominant element of the building's total design.

Accentuating Collector Mountings

A collector mounting, which tilts a collector to its proper orientation, also can be used as a design element and as a highlight for solar features. This strategy involves accentuating the collector mountings and highlighting the contrast that results from changing the planes of the collector and mounting surfaces. The accentuated mountings can be a dramatic addition to a building's design.

Figure 45 shows an active retrofit installation that uses paneled, enclosed mountings as an important feature of the building. The collectors are installed in a series of arrays, giving the roof a "sawtooth" appearance and emphasizing the collectors. Similar approaches could be considered for clerestory dormers or skylights in passive installations.

Figure 45 Sawtooth Roof Highlighting Collectors

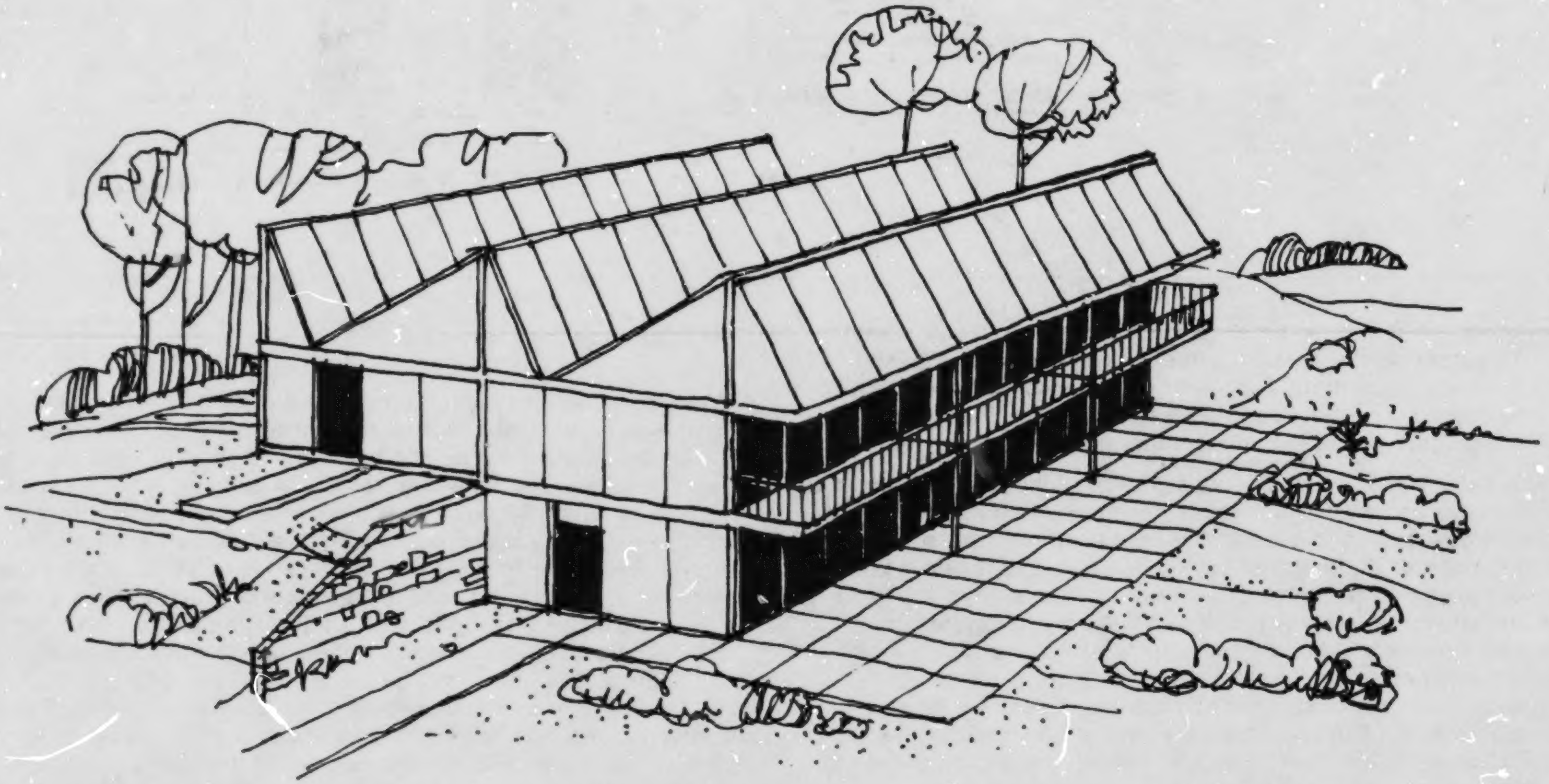


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Figure 46 Separate Collector Mountings Highlighting Solar Features

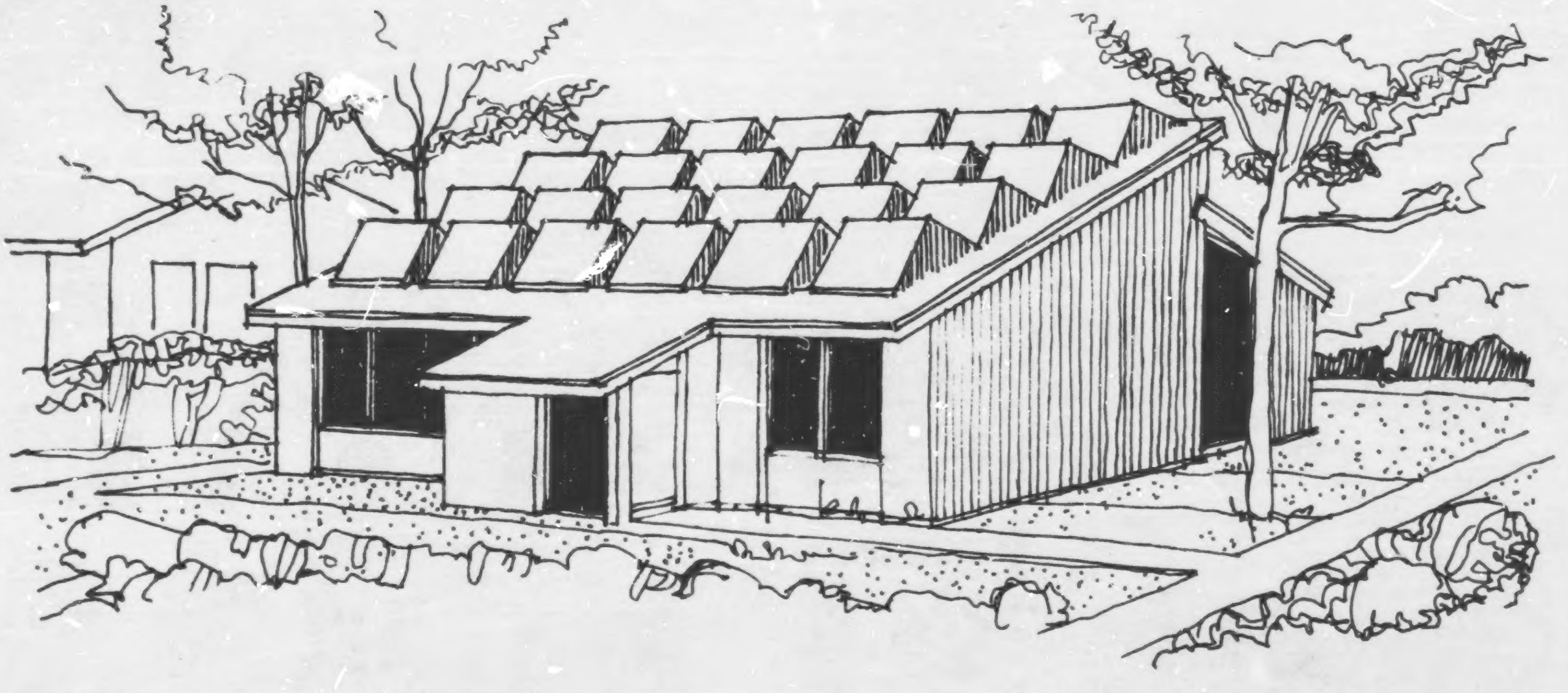

Figure 46 shows a variation of this idea. In this actual retrofit installation, the individual collectors are not installed as one continuous array. Instead, each collector module has its own separate mounting. This installation creates a unique and dramatic design that highlights the solar system. Modifications of this approach, less radical in appearance, are possible for a wide range of housing styles, provided that the building is compatible with neighboring homes and buildings.

Passive glazing also can be emphasized by setting it off from the plane of the wall or roof. The most common situation occurs when a solar greenhouse is designed for a new building or installed on an existing building. Figure 47 shows an example in which a greenhouse dominates the building's design.

Accentuating the Mechanics of Solar Installations

Some solar applications require extensive mechanical equipment. Solar air conditioners, for example, may require the use of evacuated-tube or concentrating collectors on tracking mountings to generate sufficient temperatures to operate the air conditioning system. Such installations may require complex mountings, motors, chain-drive systems, and shiny, metallic collectors with prominent reflectors. Some designers may choose to expose such features in order to create an industrial appearance. Figure 48 illustrates this approach.

The acceptability of this approach depends mostly on where the building will be located. In many neighborhoods with traditional architecture, the design review boards may feel that this approach

Figure 47 Highlighting Passive Collectors

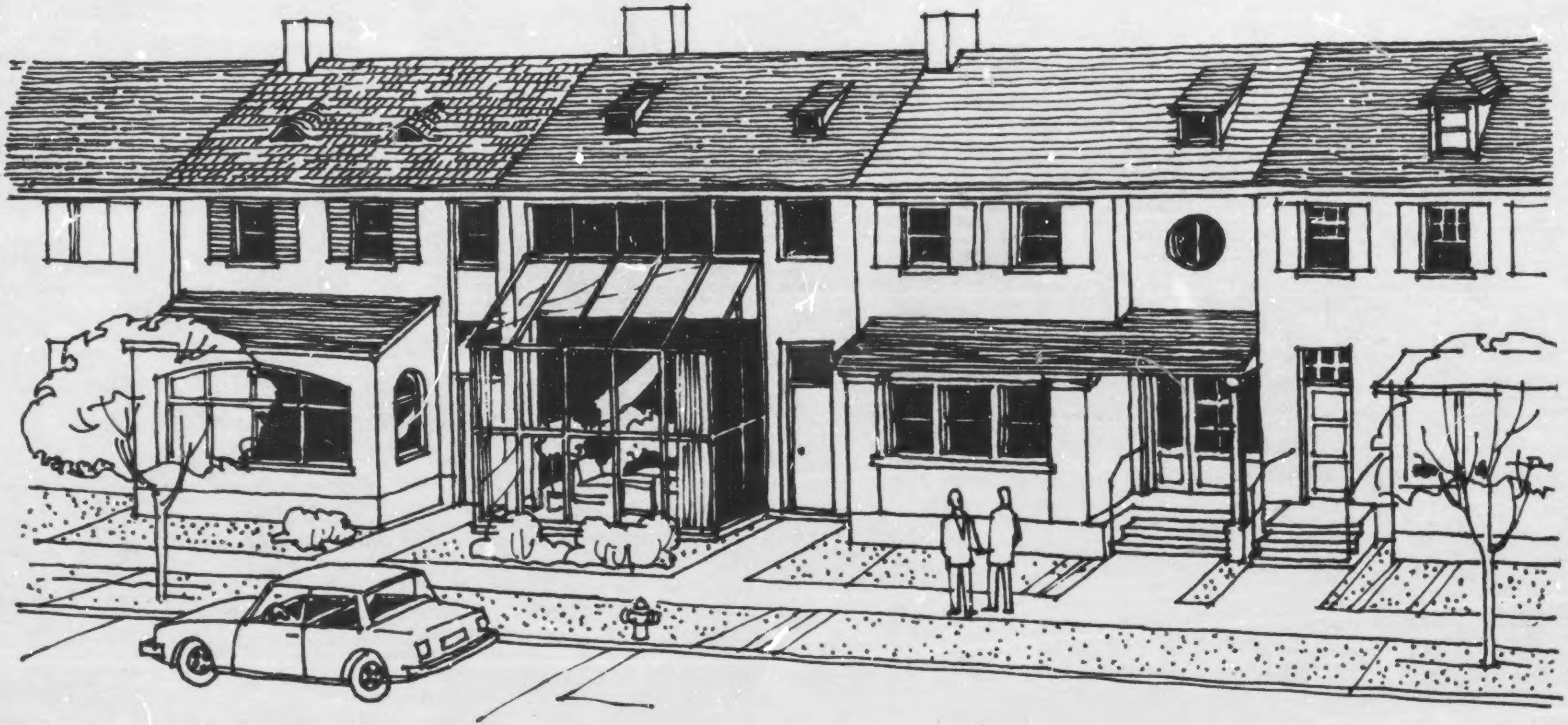

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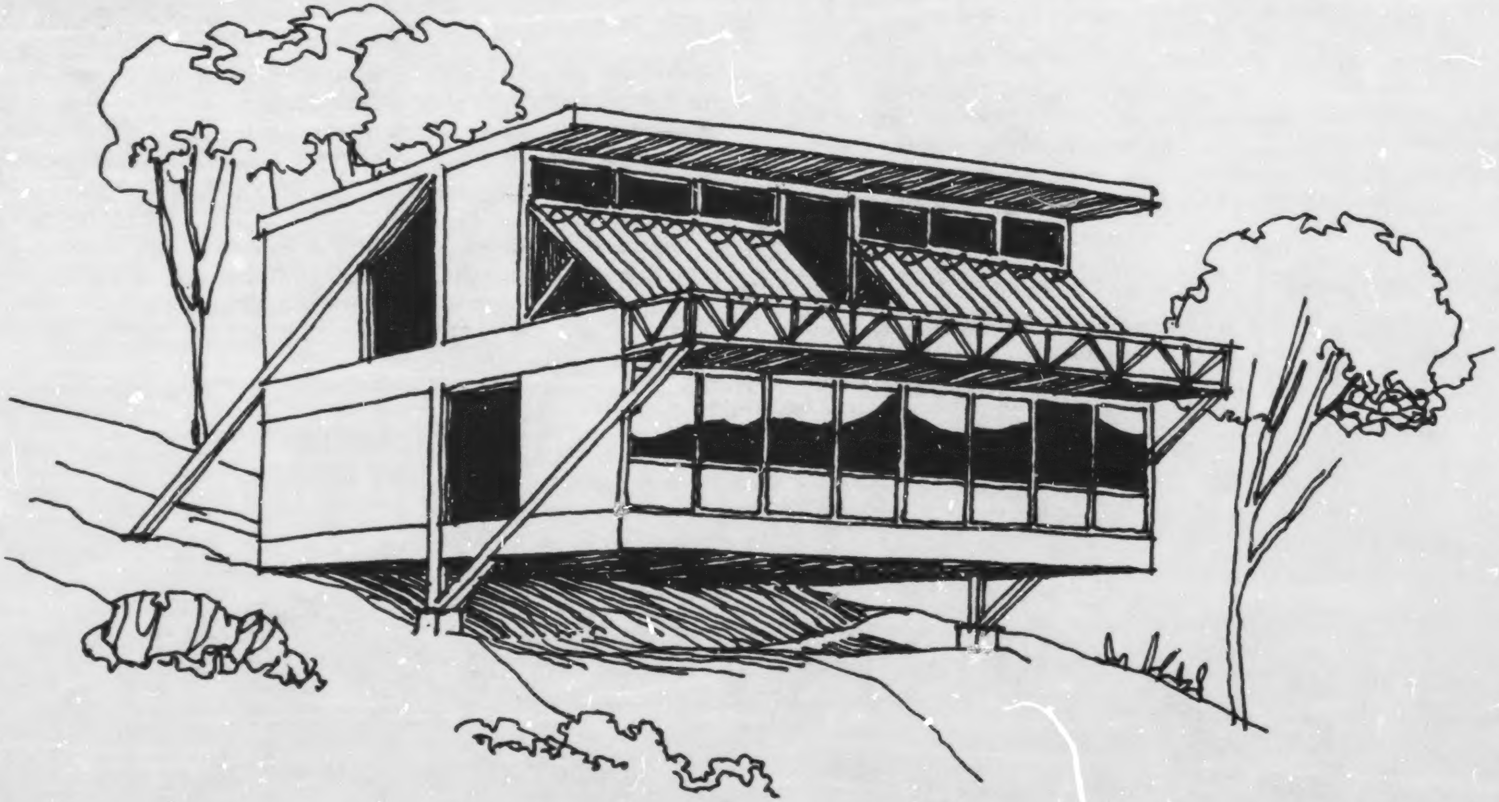
Figure 48 Emphasizing Solar Equipment as ''High Tech'' Design



is inappropriate. However, in other locations, such as large lot suburban settings or neighborhoods with many buildings of contemporary design, the treatment may be appropriate.

Integrating Solar Buildings into Neighborhood Settings

These techniques are aimed at helping to blend solar collectors into the buildings in or on which they are installed. Designers and review boards may also be concerned with integrating solar buildings, especially newly constructed ones, into surrounding development.

Building integration will be especially important in historic districts or when a solar building is going into an established neighborhood that already has a distinct architectural style. With the increased interest in revitalizing older (sometimes historic) neighborhoods, architects and others have given a lot of thought to ways in which new construction can be designed to respect and complement older architectural styles. Many fine examples of such ''infill'' development can be found in our cities. Design techniques are often very subtle, evolving from site-specific situations. One particular historical style, for example, would lend itself to an innovative contemporary treatment of roof lines while another would not.

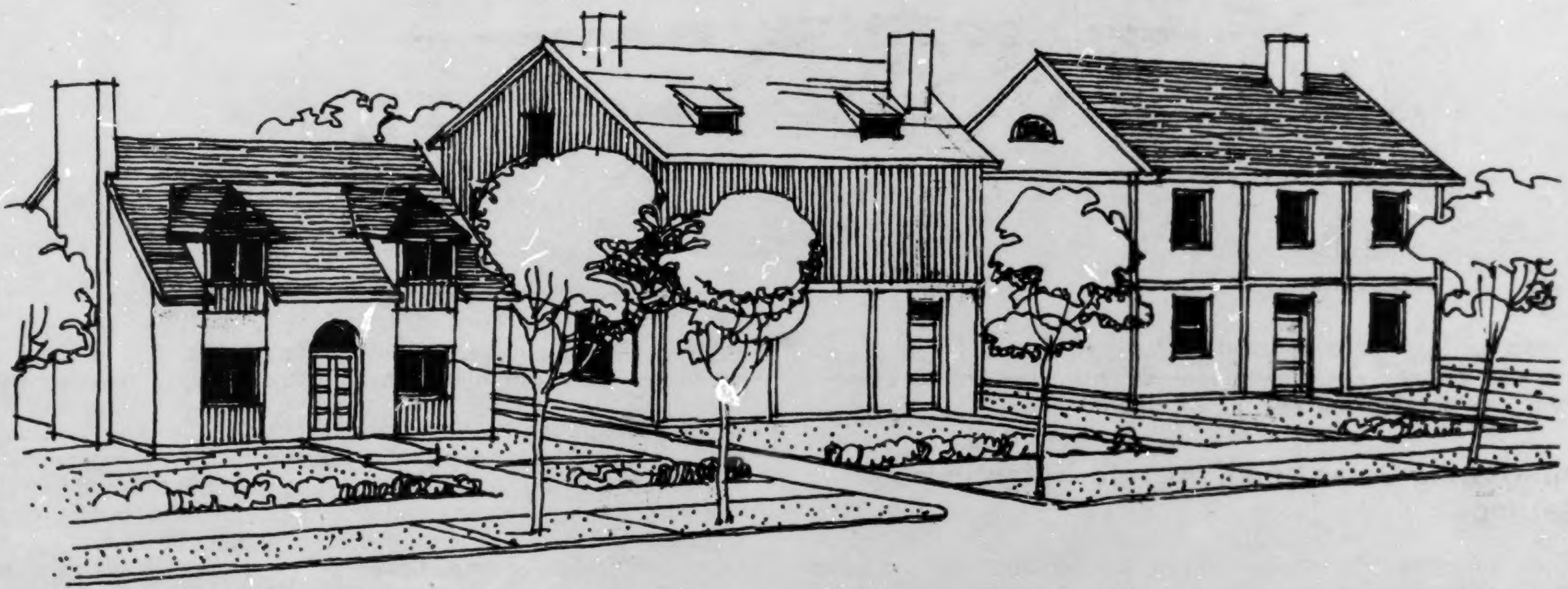
Providing guidelines for integrating buildings into their surroundings is more difficult than doing so for collectors. The suggestions given here will be elementary and obvious to many architects and review board members. For individuals with less experience in design review, though, these suggestions can point out the more basic ways to reduce the impact of solar buildings on the neighborhoods in which they are built.

Compensating for the Lack of Windows

Many solar buildings, especially those that use passive systems, have few windows on the north, east, and west sides. As we have mentioned, north windows are sources of great heat loss in the winter; and east and west windows cause overheating of the building in summer.

Especially when one of these facades faces the street, the solar building looks noticeably different because it has fewer windows than conventional buildings nearby. The use of trim or other design accents similar to those on neighboring buildings can compensate for the lack of windows and break up the facade in the same way that windows would. For example, if a solar building's neighbors have wood or painted trim, the same type of decoration could be applied to the front of the solar building to make up for the lack of windows and to relate it to the other buildings. Figure 49 shows how this may be done in an extreme example of a building with no north windows.

Figure 49 Trim Used to Compensate for Lack of Windows



Using Design Elements from Surrounding Buildings

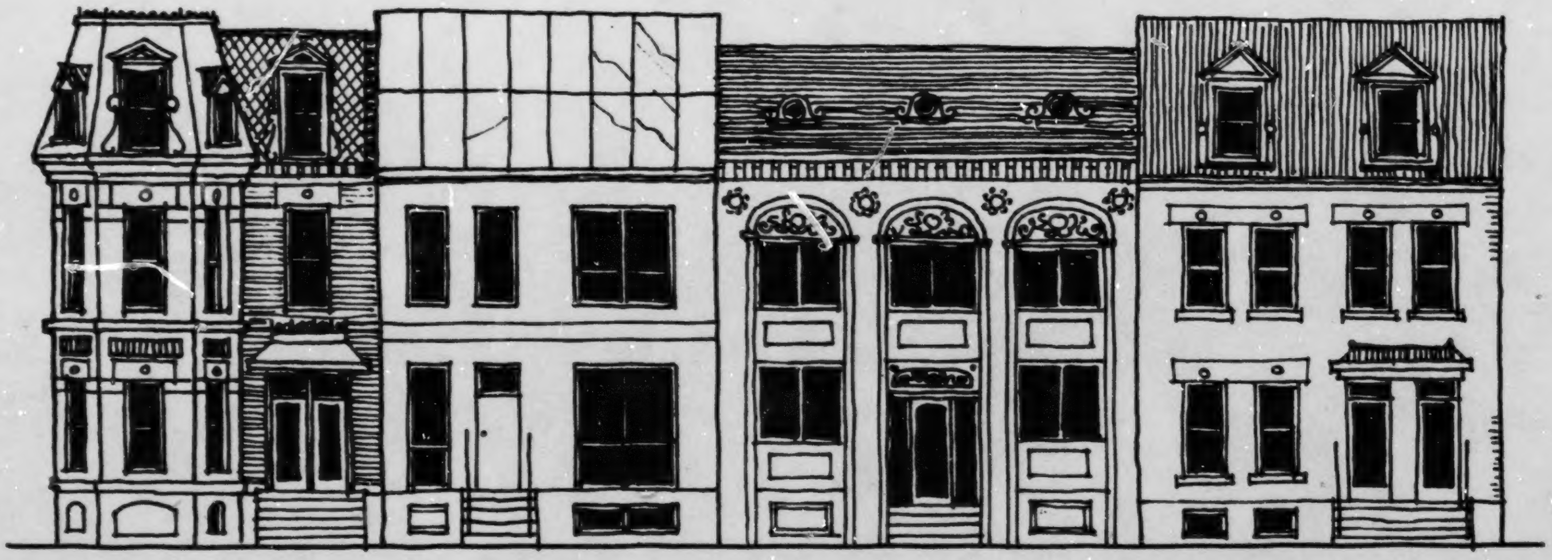
One of the methods that architects use to integrate new buildings into developed areas is to repeat the lines and details of neighboring buildings in their designs. Some good examples are the numerous infill row houses that have been designed for and built in old neighborhoods in cities such as Baltimore and New York City.

Rather than reproduce the identical architectural styles and features of the older buildings, many designers use selected architectural features to establish a sense of belonging for their new buildings. The bulk, color materials, and horizontal lines of the eaves, roof, windows, and moldings are used selectively to maintain continuity of design with the older, neighboring structures. Similar techniques can be used for detached housing as well as row housing.

To a great extent, these techniques can be used to blend solar buildings into their existing neighborhoods. A solar designer can maintain the pattern, symmetry, and continuity of the neighborhood by repeating certain design features of nearby buildings. Where a collector array will be visible in the front of the building, this treatment can compensate for the solar equipment. Figure 50 shows a solar building integrated into a row of existing structures. Note that the solar building does not necessarily have to copy all of the design flourishes and trim of the older structures to give the appearance of belonging. Matching up the lines of windows and eaves and maintaining the size and proportions of windows establishes continuity for the structure, even when its colors, materials, or window details may differ radically from the existing buildings.

The design strategies of concealing, integrating, or highlighting solar collectors presented in this chapter are by no means the full range of design alternatives. Local architectural review committees and design review boards may develop other design strategies that meet the needs and desires of their own communities. The design

Figure 50 Integrating New Solar Buildings into Rowhouse Development



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strategies discussed in this guidebook are a starting point for developing other flexible design approaches to better accommodate the special design concerns of a particular neighborhood or community.

The burden of developing good solar design strategies should not fall solely on the architect or designer. Architectural review committees and design review boards should take the initiative in generating design guidelines for solar development, and should reevaluate existing aesthetic controls and objectives in order to encourage solar energy use. The next chapter goes a step further and examines how the design review process and design criteria can be changed to better accommodate solar buildings and installations.

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Making Design Review More Responsive to Solar Energy Use

Re-Interpreting Design Criteria
Adding Solar Design Criteria to Design Review
Changing the Design Review Process
  Purpose and Intent
  Expanding Review Board Membership
  Preliminary Meetings for Solar Proposals
  Reviewing Solar Buildings as a Special Classification
  Solar Design and Design Review—The Common Ground

There are ways to resolve any conflicts between design review and solar energy use. One way is to use the design options presented in the previous chapter to change the appearance of solar buildings so that they meet local design review objectives. Another approach is to change the design review process itself to remove barriers to solar buildings and promote solar energy use in a community.

Communities can consider several strategies to change the design review process. One approach is to retain the design review procedures and requirements but to change their interpretation to allow solar installations and solar buildings. Another approach is to add special solar design criteria to design review and delineate specific aesthetic goals for solar buildings in addition to the design objectives required for conventional buildings. Finally, communities can change the scope, membership, and procedures of design review boards to favor solar buildings and to promote the use of solar energy.

Re-Interpreting Design Criteria

Design review boards and historic preservation commissions assess buildings by using design guidelines or criteria defined in the restrictive covenant provisions or local ordinances dealing with design review. These criteria usually are very general, with broad statements such as "New development shall be compatible with its surroundings," or "Plans shall display good proportion or scale."

These criteria are intended to be general, so that both the community and the architect have enough flexibility to tailor the design of a building to harmonize with the appearance of a neighborhood or site. The generalities soon evolve into very specific recommendations or design strategies as a designer proposes a specific building for a particular location and the negotiation process begins.

Broad and general design review guidelines can promote solar design as well as hinder it. If a community chooses, it can decide to interpret guidelines expressly to allow solar installations and solar buildings without changing a word of its ordinance, covenant restrictions, or regulations. All that is required is a willingness to interpret these general design statements to include any or all of the solar design strategies presented in the last chapter. Then, the major design issue that will be discussed during design review negotiations will not be whether a solar building is allowed, but rather what is the best design strategy for a particular solar building proposed for a particular location.

Conventional design criteria often cover such things as the extent of glazing, the shape and color of roofs, the types of materials used in a building, proportion and scale, and landscaping considerations. All of these factors are just as appropriate for solar buildings as for conventionally heated or cooled structures. If a design seems inappropriate for a particular location, then the design review board can suggest any of the other design strategies presented in the last chapter to minimize aesthetic conflicts. The solar equipment can be concealed, integrated, or highlighted to fit into the character and appearance of a neighborhood. This approach requires only a change in the interpretation of these criteria and a notice informing homeowners and architects that solar design is allowed under the existing standards.

Adding Solar Design Criteria to Design Review

Another alternative to expanding the scope of design criteria is to develop specific design criteria that apply only to solar buildings or to buildings using solar equipment. Solar design criteria would be used only for solar buildings and would be irrelevant to conventional development. The major benefit of this approach is that specific design objectives can be developed for solar buildings without radically changing the standard design review process.

Several communities with design review boards have developed such special solar criteria. Their design guidelines are relatively broad in scope but apply mostly to active solar installations. These design criteria can be used by people installing collectors to assist in the approval of their systems by the design review boards. Also, board members can refer to the criteria as an aesthetic "yardstick" when solar energy system proposals are reviewed.

The *City of Palo Alto, California*, is considering proposed guidelines for the installation of solar collectors on single-family residences. The design criteria are brief and address two main areas of design—placing the collectors on the building and minimizing the appearance of the collectors, the piping or ductwork, and the frame mountings.

Specific guidelines cover such concerns as locating collectors to minimize the need to remove or trim trees and to avoid glare onto neighboring properties. (Well-designed solar installations should not create problems with glare.) Strategies for painting or coloring visible piping, or using colors to blend the collector frame into the rooftop, also are presented in order to minimize the contrast between the solar equipment and the rest of the structure.

The Palo Alto report presenting the design criteria goes further, and discusses options for applying the guidelines. The report suggests that homeowners who are planning to install solar collectors be given free architectural assistance to help them meet the design objectives. This assistance would provide more detailed information than the guidelines alone could offer. The accompanying report also suggests that solar buildings be treated differently from conventional buildings. Proposals for solar installations would be routed to the planning department before architectural review, so that the application can be rated according to the guidelines. Installations having only minor effects on a building's design or appearance would be granted a building permit immediately, while installations with greater design problems would require full design review before a buiding permit could be issued. The specific design guidelines are presented in Appendix B, and the rating system used to distinguish between major and minor installations is discussed later in this chapter.

The Architectural Committee of Columbia, Maryland, was concerned with the design implications of solar energy use and also developed guidelines for installing solar collectors on residential buildings. Their guidelines address the orientation of lots for new houses and the use of ground-mounted collectors when buildings are improperly oriented. Design criteria also address such issues as using fences to screen collector installations, concealing collectors, and placing collector arrays on rooftops.

Some of the design guidelines are quite specific. For example, the proposed design criteria suggest that large arrays on flat roofs should be set back from the eaves and concealed from ground-level view by a parapet, unless the collector array is intended to be a design feature of the building. Smaller collectors are to be located midway along the roof ridge to simulate skylights. Unconventional glazings (such as fiberglass) are prohibited, as is exposed piping. Collector frames must be painted to match adjacent roof surfaces or the house trim. Appendix II shows some of the specific design criteria used by this community.

A third set of guidelines was developed by *Armond Piscopo of Gaithersburg, Maryland.* Mr. Piscopo was denied permission by his homeowners' association to install solar collectors on his home. He developed these design guidelines and directed them specifically to private homeowners' associations, so that similar conflicts will not arise elsewhere. The design criteria govern the style of the collector panels, the color of the panels, their arrangement and location on a house, mountings, piping, and ductwork, and a liability clause. These design criteria are presented in their entirety in Appendix II.

All of these design guidelines or criteria are an attempt to address a difficult problem—presenting many of the solar design issues in a form that is useful to citizens and design review boards. By necessity, such criteria must be flexible and broad, recognizing that each installation has a unique set of characteristics and must be considered on an individual basis.

Changing the Design Review Process

Design review regulations that limit the use of solar energy can be altered so that the regulations or the review process takes into account the validity of solar energy use and the design issues associated with it. There are four areas where changes are important. First, the purpose of design review and historic preservation regulations can be augmented with an official policy about the review of solar energy systems and buildings that can use them. Second, the composition of design review and historic preservation boards can be expanded to include members who are familiar with solar energy use and its associated design issues. Third, preliminary review meetings, which help to avoid problems in the review and approval of controversial or unusual proposals, can be encouraged or mandated for solar buildings. A board may wish to treat solar buildings differently or even to exempt them from review in some cases.

Purpose and Intent

If a community is concerned about encouraging the use of solar energy, it can consider adding specific solar energy objectives to the purpose clauses of their regulations. A simple phrase such as the following could be used:

> This [ordinance or declaration of restrictions] is to promote and encourage the use of solar energy for residential, commercial, and industrial purposes, consistent with improving and maintaining the standards of good design and appearance as set forth in [name of regulations or architectural review restrictions] of [City or Development].

This addition to the conventional purpose and intent language would clarify the community's intentions about solar energy.

Making this change in the purpose clauses of historic preservation regulations is especially appropriate. At present, it is very difficult to introduce the use of solar energy into historic district settings. However, many historic preservation regulations specifically refer to upgrading, repairing, and maintaining buildings so that they can be returned to service.

For example, one of the objectives of conserving the West Freemason Historic District in Norfolk, Virginia is "to accommodate functional needs of the present without disrupting the character of the past" and "to encourage adaptive uses where continuation of the original use is no longer economically feasible." The use of solar energy and energy conservation in general is consistent with the spirit of such objectives. In light of rising energy costs, solar energy may be an important part of a program to save some historic buildings.

Substantial attention has already been paid to energy conservation in historic buildings. The office of Archeology and Historic preservation of the U.S. Department of Interior has prepared a Preservation Brief discussing a number of energy-conservation options. The Brief, "Conserving Energy in Historic Buildings," does not specifically address solar energy use or solar retrofits, but it does suggest that there is an interest in upgrading buildings for more efficient energy use.

Individual renovations using solar energy in some historic districts are also being considered. The Oakland Hotel in Oakland, California, a building with significant historic interest to the community, is presently being retrofitted with a solar water heating system that will provide about 50 percent of the building's hot water needs. The White House in Washington, D.C., has already been retrofitted. An architect has designed and built a solar building in the historic district of Alexandria, Virginia; the design was reviewed and approved by that community's historic preservation commission.

Like review boards that have amended public and private design regulations and restrictions, historic preservation commissions may wish to consider adopting a specific solar policy within the purpose clause of their ordinances.

Expanding Review Board Membership

When a community decides to encourage solar energy use or when it finds itself facing an increasing number of proposals for solar heated or cooled buildings, it may benefit from appointing individuals who know about solar energy design to its review board. The community could choose to increase the number of members on the board or replace members whose terms have expired.

The advantage of this approach is that a board member would be familiar with solar energy systems and their technical requirements. The applicant is assured of a knowledgeable contact on the board, and the board can rely on a member who can make reasonable and informed suggestions about how a proposal could be more effectively modified to meet the regulations.

Typical requirements in design review and historic preservation regulations state that boards shall consist of licensed landscape architects, contractors, architects, and individuals who have demonstrated a knowledge of design and the visual arts. Many individuals interested or involved in solar energy will meet these specifications. The following options for expanding board memberships can be considered:

Option 1:	Add a "licensed architect experienced in the design of buildings using solar energy for heating and cooling purposes . . . ."
Option 2:	Add "a licensed contractor experienced in the design and construction of buildings that use solar energy for heating and cooling purposes and the installation of solar energy systems on existing buildings . . . ."
Option 3:	Add "a representative of the community who has demonstrated a knowledge of, or experience in, the use of solar energy for heating, cooling, or water heating and also in design and the visual arts . . . ."

Preliminary Meetings for Solar Proposals

A third procedural change can be made to accommodate a concern for solar procedural energy into design and historic preservation review—encouraging or requiring preliminary informal review for proposals that include the use of solar energy. Solar developments could benefit from a preliminary meeting with board members to familiarize the board with early plans and iron out initial conflicts before the plans are finalized. For example, Coral Gables, Florida, found that many aesthetic problems with solar installations were easily solved when solar installers first met with the local Board of Architects.

Many design review regulations already encourage or require a preliminary meeting, especially for major projects. For proposals that involve solar energy systems, especially new construction, the board can make a strong effort to get developers and citizens to submit early plans. A preliminary meeting is probably not necessary for solar domestic hot water installations. Plans for such proposals are usually not so complex that they cannot be easily changed.

Reviewing Solar Buildings as a Special Classification

As an alternative to completely exempting solar buildings from design review, a community could create a special solar classification in its own review procedures. Some control could be exercised over their design, but they could be given special consideration as solar buildings.

Establishing a special review category for solar energy systems and buildings is similar to the two-level review processes used by some communities (like Beverly Hills, California) in conventional design review. Development proposals are separated into major and minor categories. The major proposals, which cover developments over a certain number of units or acreage, are subject to more extensive board review than minor proposals. More information must be submitted with the application for a major proposal and a formal procedure must be followed. Minor proposals are often reviewed by an administrator; they do not go before the design review board at all. This approach would be appropriate for the installation of solar collectors on existing buildings, when such installations would not be very noticeable or visible on a building. Solar water heating systems, for example, could be classified as minor proposals, exempt from full design review.

This is the approach being considered by Palo Alto, California, in its proposed solar installation guidelines. As discussed earlier, the proposed design criteria create a rating system to divide solar proposals into developments requiring design review and developments that can be granted a building permit by the planning department without design review. In order to make this distinction, the proposed design guidelines establish a rating system based on the community's design objectives. Each design issue is given a rating—the more important design factors being rated highest—and evaluated according to a checklist. If the checklist adds up to more than 1.5 points, then the proposal requires full design review; but if it adds up to less than 1.5 points, then the planning department can immediately issue a building permit for the solar installations. The table is shown below, along with the weights given to each design factor.

Proposed Palo Alto Solar Installation Rating System[1]

Add total points on each item checked in the "yes" column. If total is over 1.5, Planning staff makes design suggestions prior to issuing building permits or suggests ARB review.

	No	Yes	Rating
1. Do collectors reflect into neighboring windows?			1
2. Is installation visible from the street?			1
3. Will trees be removed or trimmed?			1
4. Is installation higher than ridge line?			.5
5. Does installation stand more than 3' above the roof surface?			.5
6. Is the color of collector frames compatible with the roof?			.5
7. Is the piping visible and does it blend with the surface it is attached to?			.5
8. Are the ends of the panel arrays not covered or are mounting brackets visible?			.5

If a community wishes to actively promote solar energy use as a specific policy, it can carry this policy a step further. A member of the public design review board of Davis, California, recently wrote:

> The design Review Commission deliberately encourages developers to incorporate visible solar features in their buildings. In most cases, when someone submits plans incorporating solar devices or features, the commission refrains from making aesthetic judgements, believing that the positive symbolic effect of the solar features far outweighs any possible problems with design considerations, such as proportion or contrast.[2]

Private and public design review boards can consider this strategy if solar energy use is widely supported in the community. Most communities, however, will probably choose less drastic alternatives, modifying design criteria or the design review process itself to better accommodate solar development.

Solar Design and Design Review—The Common Ground

Like the previous chapter on solar design strategies, this chapter can be seen as an overview of alternatives that can be considered by local design review boards and committees in developing their own programs to resolve conflicts between design review and solar design. The list of possible modifications to design criteria and design review procedures can easily be tailored to meet the requirements of local programs and local design objectives.

In examining alternative design strategies or design criteria, communities should begin to realize that there does not have to be a conflict between design review and solar energy use. If a community understands that solar energy alternatives are one way to deal with shrinking energy resources, and if homeowners and designers recognize the flexibility inherent in solar design, then they will negotiate with each other across a common ground. Design review is one way for communities to insure that the general welfare will be promoted by encouraging buildings appropriate for their settings. Solar design review is merely an extension of that premise.

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[1] City of Palo Alto Staff Report: Proposed Solar Guidelines, July 11, 1978.

[2] Robert Thayer, Jr. "Bringing Solar Design Out of the Dark Ages," Planning (Chicago: American Planning Association, December, 1978), p. 25.

Appendix I: Techniques of Design Review

- **State Laws Affecting Solar Design Review**
- **Design Review Regulations**
  - The Scope of Design Review
  - The Structure of Design Review Boards
  - Purposes of Design Review
  - The Design Review Process
- **Historic Preservation Regulations**
  - The Scope of Historic Preservation Review
  - The Purpose of Historic Preservation
  - The Historic Preservation Review Process
- **Private Design Review Controls**

In examining the design review process, it is useful to consider three different types of restrictions that can require prior review and approval as part of the development approval process. These are public design review ordinances or regulations, public historic preservation ordinances, and private design or architectural review approvals administered by a committee of property owners within a residential development project. All of these techniques are similar in scope and application, although slightly different in administration and form. All essentially do the same thing—give the community a chance to see what will be built before it is built and give the community the power to approve the design or appearance of the building prior to construction.

Because public design review controls—design review ordinances and historic preservation regulations—differ in legal form and structure from design review committees created by private covenants within a homeowners' association, it is useful to discuss each of these techniques separately. Both public and private design review approaches can benefit from the same strategies in dealing with solar development. Alternatives that allow the accommodation of solar design in the design review process will be presented for all three techniques.

There are two types of controls that regulate aesthetics in residential development. The first type is known as design review, and the public regulations and private restrictions apply to new residential development as well as to modifications or additions to existing buildings. The second type of public aesthetic control is historic preservation regulations, applying to historic buildings or development within designated historic districts. Design review attempts to create an image of aesthetic significance within a community, while historic preservation regulations attempt to promote and maintain an aesthetic significance that already exists.

Some residential development using solar technologies for space and water heating, or space cooling, may conflict with these broad public objectives. The extent of this potential conflict depends not only on the design of a particular building and its relationship to surrounding development, but also on the scope of the public regulations themselves and how they are administered. Descriptions of these public regulations governing aesthetics and building design are given below.

State Laws Affecting Solar Design Review

The overview of design review techniques discussed in this appendix will apply to communities in most states. But a few states have adopted specific legislation that affects the design review of solar buildings. Generally, these laws will not allow a community to unreasonably restrict the use of solar energy systems by any local ordinance or covenant restriction. This legislation will obviously affect the review of solar buildings under public and private design review requirements.

In 1978, the General Assembly of California passed Assembly Bill No. 3250, adopting the California Solar Rights Act of 1978 (Cal. Stats, Ch. 1154, 1978). Section 6 of the Solar Rights Act amended section 65850.5 of the Government Code to read as follows; provisions of the Health and Safety Code also were amended.

> 65850.5. The legislative body of any city or county shall not enact an ordinance which has the effect of prohibiting or of unreasonably restricting the use of solar energy systems other than for the preservation or protection of the public health or safety. This prohibition shall be applicable to charter cities since the promotion of the use of nonfossil fuel sources of energy, such as solar energy and energy conservation measures, is a matter of statewide concern. This section shall not apply to ordinances which impose reasonable restrictions on solar energy systems. However, it is the policy of the state to promote and encourage the use of solar energy systems and to remove obstacles thereto. Accordingly, reasonable restrictions on a solar energy system are those restrictions which do not significantly increase the cost of a system or significantly decrease its efficiency, or which allow for an alternative system of comparable cost and efficiency.

Design review by private committees of homeowners' associations would also be affected by this legislation. Section 3 of the Solar Rights Act amends Section 714 of the state Civil Code to read:

> 714. Any covenant, restriction, or condition contained in any deed, contract, security instrument, or other instrument affecting the transfer or sale of, or any interest in, real property which effectively prohibits or restricts the installation or use of a solar energy system is void and unenforceable. This section shall not apply to provisions which impose reasonable restrictions on solar energy systems. However, it is the policy of the state to promote and encourage the use of solar energy systems and to remove obstacles thereto. Accordingly, reasonable restrictions on a solar energy system are those restrictions which do not significantly increase the cost of the system or significantly decrease its efficiency, or which allow for an alternative system of comparable cost and efficiency.

The Colorado Assembly recently adopted a similar provision, according to 1 Solar Law Reporter 547 (1979: Solar Energy Research Institute). Senate Bill 133 voids "unreasonable" covenants and other aesthetic restrictions on the use of real property which "effectively prohibit or restrict" solar installations. Although this provision is worded similarly to the California Solar Rights Act provision, it differs in confining "reasonable"restrictions only to restrictions that do not increase the cost of the solar installation.

These legislative provisions do not bar solar buildings from design review. What they do is restrict the scope of design review, allowing solar energy installations to be barred in some circumstances (where the public health or safety would be affected), but allowed by right in most situations. It is likely that the decisions of a design review board can still affect where and how solar collectors are placed on buildings, and how non-solar elements of the building's design will look. But the line defining a "reasonable"restriction and an "unreasonable" impermissive restriction is ambiguous and will probably have to be defined on a case-by-case basis. Design review boards in California and Colorado should proceed cautiously in their review of solar buildings and solar installations, so as not to violate these statutes and have their decisions voided by the courts.

Design Review Regulations

Design review regulations encompass a variety of aesthetic controls, including architectural controls, site plan review requirements,

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and appearance codes. Generically, all of the specific types of regulations can be classified as design review regulations. As a class of public regulation, all function similarly, are adopted for similar purposes, and are administered in similar ways.

Design review regulations are often administered by a design review board, consisting of appointed members who review development proposals for their aesthetic effects as part of the local permitting process. Projects are reviewed according to criteria or standards established in local design review ordinances, and a board may (1) approve; (2) disapprove; or (3) make recommendations about design issues raised in the specific development proposal. By using design review, a community can review the appearance as well as the physical aspects of a proposal before it is actually built.

The Scope of Design Review

Design review regulations rarely apply to all development within the community. It can apply to certain classes of development or to development occuring in certain designated locations or districts within the community. For example, the design review process may involve only projects above a certain size or associated with a certain activity (e.g., commercial or industrial development).

Typically, the types or classes of development that fall under the scope of public design review regulations are largely non-residential. Design review is a common requirement in many commercial districts of many communities, as a requirement of the approval of the commercial use. To this extent, a great deal of the public design review process lies outside the scope of this guidebook, which is concerned only with solar energy use in residential development projects or buildings.

Fewer communities require design review for certain residential projects in addition to non-residential uses. Larger scale, multifamily developments are reviewed by a design review board in some communities, and planned unit developments (PUDs) frequently involve aesthetic review and approval as well. Only a small handful of communities extend the scope of design review to individual, detached, single-family residential structures.

Four alternatives can typically be considered by communities in defining the scope of design review. A guidebook by the American Institute of Architects' Committee on Design, Design Review Board: A Handbook for Communities, lists the four options exercised by communities considering design review controls. In all four options, "development" is defined to mean "that no site shall be cleared or altered, nor shall any structure be erected, demolished, moved, altered, or enlarged without the approval of the design review board. . . ."

Section 1-012. Types of Development Included:

> Option 1: This ordinance shall apply exclusively to municipal development, and, to the extent municipal design review is not pre-empted by state or federal law, other government development.
>
> Option 2: Except as provided hereafter, this ordinance shall apply to all development: private, municipal, and to the extent municipal design review is not pre-empted by state or federal law, other government development.
>
> This ordinance shall not apply to detached, single-family residential structures, except those which are subject of a use permit or a variance, those in a residential district. . .or developed as part of a subdivision of more than [ ] parcels.
>
> Option 3: This ordinance shall apply to all development; private, municipal, and to the extent municipal design review is not pre-empted by state or federal law, all other government development.
>
> Option 4: This ordinance shall apply to all projects within the Design Review District as defined herein: [legal description of Design Review District].
>
> Within the above district, this ordinance shall apply to all development: private, public, and to the extent that municipal design is not pre-empted by state or federal law, all other government development.[1]

According to the AIA handbook, most communities using design review have chosen the second option, extending review to all projects but excluding single-family, detached housing. A few have established design review districts, under Option 4, which are used to preserve view corridors and to maintain architectural integrity within historically or aesthetically significant areas. This last purpose will be discussed in greater detail when historic preservation controls are discussed.

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[1] AIA Committee on Design, Design Review Board.

The Structure of Design Review Boards

Design review is the responsibility of the design review board, committee, or commission, selected by the community to make judgments about the appearance or design of development projects requiring design review. Generally, such boards are small, seldom exceeding seven members, and are appointed (rather than elected) for a specific term, generally without compensation.

Some communities may decide not to use a separate design review board, but, instead, to extend the authority of an existing planning commission to include design review. This might be used in cases where design review regulations are adopted as part of the zoning ordinances (already administered by the planning commission) and not as a special-purpose ordinance requiring its own administrative body.

Various other combinations of membership are possible. Glenview, Illinois, for example, requires that an "owner, or an officer of a corporation owning business, commercial, or industrial property" be represented on its five member Appearance Commission (Glenview, Illinois, Ord. No. 1607, 25.3-1, 1959). Scotch Plains, New Jersey, requires the local building inspector as well as planning commission members to be represented on its architectural review board.

Purposes of Design Review

The stated purpose of most design review regulations is to promote the public health and welfare through the preservation of property values and the aesthetic quality of the community. This stated purpose is linked to conventional legal authority (the police power) of communities to zone or regulate for the public good.

Where design review regulations are part of a zoning ordinance, then the purpose and intent clauses of the zoning may support the aesthetic controls within the design review provisions of the zoning ordinance. Where the design review controls are adopted as a separate ordinance, a specific list of purposes and policies may be included as part of the ordinance.

The Glenview, Illinois Appearance Code has a fairly typical range of purposes cited to justify the aesthetic controls:

A. To promote the public safety, health, morals, comfort and general welfare of said Village.

B. To enhance the values of property throughout said Village.

C. To protect and stabilize the general appearance of buildings, structures, landscaping, and open areas, in the multiple dwelling, business, commercial, planned development, public lands, hospital, and industrial zoning districts of the said Village.

D. To insure adequate light, air, and privacy for property in the multiple dwelling, business, commercial, planned development, public lands, hospital, and industrial zoning districts of said Village.

E. To encourage and promote acceptability, attractiveness, cohesiveness and compatibility of new buildings, development, remodeling, and additions so as to maintain and improve the established standards of property values within the multiple dwelling, business, commercial, planned development, public lands, hospital, and industrial zoning districts of said Village.[2]

Purpose clauses of other design review ordinances surveyed by the American Planning Association are similar to Glenview's stated purpose provisions. Generally, a statement linking the regulations to the traditional purposes of public regulation under the police power—the promotion of the public health, safety, morals, and general welfare—are incorporated into the ordinance, followed by a statement of general design policies linked to the preservation of property values within the community.

The Design Review Process

Ideally, the design review process is initiated with an informal meeting between a member of the design review board and an applicant proposing a project that requires design review. The applicant is often the contractor, builder, or architect for the project, although the owner of the building may also seek guidance from the board at this early stage of the proposal.

The standards, procedures, and design criteria are often discussed at this stage, and potential design issues that the project may raise are identified. Beverly Hills, California, for example, is one community which allows preliminary review in its municipal design code:

> Section 10-3.3009. Procedures. (a) Preliminary sketches of the design of a proposed structure or alteration may be submitted to the Planning Department for informal review so that an applicant may be informed of Architectural Commission policies prior to

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[2] Glenview, Illinois. Appearance Code. 25.2. (Ord. No. 1903, 1974).

> preparing working drawings. If approved, such sketches shall serve as a guide in further consideration of the same proposed building or structure.[3]

Some communities, such as Highland Park, Illinois, and Santa Barbara, California, make preliminary review mandatory, rather than discretionary. But other communities, such as Scarsdale, New York, and Concord, New Hampshire, leave the preliminary review stage of the process up to the developer. These communities have found that, as more people become familiar with the design review process, they increasingly tend to exercise their options for preliminary review early in the project.

The second stage in the design review process begins when a formal application is made to the board, and the project is considered at an open meeting for the board's consideration. All projects may be reviewed directly by the board, or the board (such as in Scottsdale, Arizona) may delegate certain minor development projects to its staff for review and recommendation.

The applicant's submission requirements to the board vary from community to community. The provisions of Highland Park, Illinois, are perhaps typical of the type of information submitted to the board along with the application.

> (3) At the time of the hearing, the applicant shall provide the Commission with the following: drawings which shall include plans and existing elevations; site plans; landscaping and screening plans (showing the location of existing trees); renderings and specifications of signs; and a statement as to kind, color, and texture of materials (all the foregoing documentation to be drawn to scale) . . . .[4]

The documentation and design plans are often reviewed by the board in the course of a formal public hearing, or as is often the case, the meeting may be relatively informal with few administrative requirements (as occurs in Coral Gables, Florida, design review before its Board of Architects). In either case, the findings of the board are set forth in a resolution, stating the board's findings and its decision. The formality of the resolution is necessary to preserve the record of the decision if it should be legally or administratively challenged.

A design review board may approve, conditionally approve, or disapprove the project. If the project is disapproved, then the applicant must submit another proposal more in keeping with the design objectives and criteria of the board. Alternatively, the same project may be resubmitted, incorporating suggestions made by the board during its public hearing.

The third and final stage of the design review process depends on the decision reached by the design review board and on the actions of the applicant subsequent to that decision.

If the project is approved, then the file and decision are forwarded to the building inspector responsible for issuing the necessary permits for the project to proceed.

If the project is conditionally approved, then the decision, with its conditions, is forwarded to the building inspector so that permits may be issued subject to the conditions. Compliance with design review conditions will be enforced along with compliance with other local ordinances and codes affecting the development.

If the project is disapproved, then the applicant may modify the proposal and resubmit, or may choose to appeal the board's decision to an administrative body, or, in some cases, to the courts.

Design review ordinances and provisions often allow appeal to a city council or other body. Appeals are allowed if the conditions imposed by the board are also unacceptable to the applicant. Scottsdale, Arizona, for example, allows appeals from recommendations made by design review board staff by allowing the applicant to bring the project directly before the entire design review board. Medford, Oregon, and Palo Alto, California, allow appeals directly to the city councils of those communities. When administrative appeals have run their course, have failed, or are still unacceptable to the applicant, then recourse to the courts is possible.

Historic Preservation Regulations

Historic preservation regulations are very similar to design review regulations in their administration and format, but dissimilar in their intent and purpose. The purpose of historic preservation regulations is to preserve the historic and cultural significance of existing buildings or areas of a community. Examples of areas and types of buildings protected by these regulations include Washington, D.C.'s Georgetown area and New Orleans' Vieux Carre district.

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[3] Beverly Hills, California. Municipal Code. 10-3.3009 (1973).

[4] Highland Park, Illinois. Appearance Code. 176.160(C) (3). As amended, 1976.

Like design review regulations, historic preservation controls establish review procedures for scrutinizing the quality of design of rehabilitation and new structures within a certain district or districts. The review is often carried out by a special historic preservation or landmarks commission, but sometimes a design review board will double as the body that reviews proposals for historic districts.

The Scope of Historic Preservation Review

Historic preservation regulations are applied in two ways. They may be applied to a single structure (or group of structures), or they may be applied to a designed historic district. Historic preservation regulations also can be written for a specific area of a community or may consist of general ordinance provisions applied to specific areas as they are designated by the community.

For example, the city planning department of the City of Norfolk, Virginia, has proposed historic preservation regulations for an area of the city called West Freemason. The area has been divided into two zoning districts, a Core District and a Transitional District, encompassing about fifteen city blocks in all. The historic designation is accomplished through the zoning ordinance. The designated areas become specific zones and are indicated as such on the city zoning map.

In addition to its historic zoning districts, Norfolk also has its historic preservation regulations applying to a single structure—the Hodges House, which is an historic estate surrounded by conventional residential development. The boundaries of the proposed designation extend only to the boundaries of the Hodges House lot, encompassing only that specific building.

Residential, commercial, industrial, or governmental structures can all be designated as historic sites or areas subject to the historic preservation controls. As Norfolk's example shows, the scope of the review can extend down to a single residential structure, as well as up to a multi-block area of the community.

The scope of historic preservation controls are defined by the designation process, generally by specific ordinance. A recommendation to designate an historic building or area generally comes from a landmarks commission and must be voted on by the local governing body (i.e., city council) of the community. The designation process often involves notification to adjacent landowners, a public hearing, and occasionally reviewing the proposed designation against state or federal guidelines for historic significance.

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Once a building or area has been designated, a number of development activities become subject to design review. For example, the model historic preservation ordinance proposed by the National Institute of Municipal Law Officers (NIMLO) states:

> Section 11-710. (a) After the designation of an historic district, no exterior portion of any building or other structure (including walls, fences, light fixtures, steps and pavement or other appurtenant features) nor above-ground utility structures, nor any type of outdoor advertising sign shall be erected, altered, restored, moved, or demolished within such district until after an application for a certificate of appropriateness as to exterior features has been submitted to and approved by the Commission.[5]

Most other historic preservation regulations surveyed take a similar approach, requiring a permit for new construction, any exterior changes to existing buildings, moving any buildings or appurtenances to buildings or demolishing buildings within an historic district. Also, zoning ordinances frequently list permitted uses with historic districts, and the specification of allowable uses within such districts is also a common provision in many regulations.

The Purpose of Historic Preservation

Like other public design review controls, historic preservation controls generally relate to the exercise of the police power by the community, focusing on promoting the general welfare. Specifically, these regulations recognize the cultural, educational, and economic value of historically and architecturally significant or unique buildings and areas, and seek to maintain this value by preserving these resources intact. The purpose provisions of the Pioneer Square Historic District in Seattle, Washington, spell these purposes out in great detail:

> Section 1. Purpose. During the City of Seattle's relatively brief history, it has had little time in which to develop many areas of consistent historical or architectural character; it is recognized that the Pioneer Square area of Seattle contains many of these rare attributes that do exist and consequently is an area of great historical and cultural significance to the City of Seattle. Therefore, in order that the Pioneer Square area and buildings within that area may not be injuriously affected; to promote the public

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[5] NIMLO. Model Historical Zoning Ordinance. 11-710 (emphasis added).

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> welfare, and to provide for the enhancement of this area and its structures, thereby contributing to the social, cultural, and economic welfare of the citizens of Seattle by developing an awareness of its historical heritage, returning unproductive structures to useful purposes and attracting visitors to the City; and in order that a reasonable degree of control may be exercised over the site development and architecture of the private and public buildings erected therein, there is hereby created a Pioneer Square Historic District (hereafter called "Historic District").[6]

Most purpose clauses are not as detailed as this one, but most contain similar provisions and purpose statements.

The Historic Preservation Review Process

Proposed development within a designated historic district often requires a permit, called a certificate of appropriateness, that is issued by a landmarks or historic preservation commission.

The application for a certificate of appropriateness generally is made to the planning, zoning, or building department of the community, and is required even if the applicant is going through other permit review procedures in addition to the historic preservation review. For example, the Seattle, Washington, regulations state that "where modification of the exterior appearance of a structure within the Historic District does not require a building or demolition permit, notice of such intention shall nonetheless be filed with the Superintendent of Buildings and referred by him to the historic preservation board." By applying to the building department, the applicant is assured that the proposed development conforms to local building codes or zoning standards before it ever reaches the stage of review by the historic preservation commission.

After preliminary review by the building or planning department, the application is transmitted to the historic preservation commission for its review and public hearing. The applicant usually presents the proposals at the regular meeting of the commission, which serves concurrently as the public hearing.

The review itself is similar to conventional design review procedures discussed earlier. The design or appearance of the project is assessed against adopted design criteria and policies and approval, disapproval, or approval with conditions are given. In Seattle, Washington, the historic review board reviews the application, makes its findings, then transmits these findings in the form of a recommendation to the planning commission, which acts on the project. In Dayton, Ohio, the historic preservation commission itself makes the final decision and transmits the formal findings and decision to the building inspector for permit issuances and enforcement. As with design review, the applicant may appeal the decision to a city council if the application is denied or conditions are unacceptable.

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The information required of an applicant as part of the review process is also similar to design review data. Information may be requested which shows sketches, drawings, photographs, descriptions, materials, fenestration, colors, and landscaping details of proposed developments in the historic district.

Private Design Review Controls

Private design review controls are similar to public techniques in structure, but they may differ from public controls in application. Where public design review is based on the public exercise of the police power (and all of the constitutional constraints affecting that authority), private design review requirements are established by contract. Generally, this contract is a restrictive covenant provision that is inserted into the deeds of all lots sold within a residential subdivision, and that requires the lot owner to seek the permission of a design review committee of a homeowners' association (HOA) before building on the lot. In granting this approval, the private design review committee examines the appearance of the proposed development and makes aesthetic judgments about the appropriateness of the design as compared to adjacent development or the appearance of other buildings within the project.

According to a report on design review by the Community Associations Institute, Design Review. . . Architectural Control (CAI-GAP Report 2, 1978), the purposes of the private design review requirements are: (1) the establishment and preservation of a harmonious design for the community, and (2) the protection of the value of property within the community. Essentially, the purpose of private design review is "to keep the community looking like a nice place to live."

Private design review procedures are often established in planned unit developments (PUDs) and are set forth in the declaration of covenants, conditions and restrictions (CCRs) of the HOA. A publication by the U.S. Department of Housing and Urban Development, the Federal Housing Administration, and the Veterans Administration, Suggested Legal Documents for Planned Unit Developments (FHA Form 1400/VA Form 26-8200. Rev. October, 1973), suggests that design review or architectural review committees be established in new PUD developments. This document contains model master declaration of CC&Rs, and authorizes, in Article IX, the appointment of an Architectural Control Committee by the Board of Directors of the HOA.

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[6] Seattle, Washington. Ord. No. 98352, as amended by Ords. 99046 and 102902. n.d.

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The CAI guidelines for community design review suggest that creation, membership, purpose, procedures, and guidelines of the design review committee be set forth in the declaration of CC&Rs of the HOA. A sample declaration cited in the guidebook states that no development will be allowed without the written approval of the Design Committee regarding: (a) the harmony of the exterior design and location in relation to, and its effect upon, surrounding structures, vegetation, topography, and the overall community design of (the PUD); (b) the character of the exterior materials; and (c) the quality of the exterior workmanship of the proposed development or alteration. The CAI guidelines suggest that detailed design criteria be set forth in the form of design guidelines adopted by the design review committee—these design guidelines should contain both design policies and specific design objectives that are applied to development proposals before the committee. Procedures for the timing, review, and approval should also be set forth within the master deed and master declaration of CC&Rs for the HOA.

Unlike public design review boards, private design review committees are not required to have architects or design professionals as a majority of their membership or even among their members. Generally, the members of the architectural or design committee are appointed from among the members of the HOA by the Board of Directors, and the size of the committee often may be smaller than that encountered in public design review boards—a three-member design committee is suggested in the CAI publication.

The legal principles governing private design review are those of contract law and real property law. Lot owners must be notified of what is expected of them; they must be given some guidance as to what constitutes proper or acceptable design (either through design policies, criteria, or standards in the covenants or design manuals of the Board); and they must be given adequate guidance as to procedures and schedules so that they can act according to the contractual provisions running with their lots. Enforcement is also through contract law, in contrast to public design review requirements, which are often enforced through local criminal law processes. Violations are often negotiated between a lot owner and the design committee of the HOA, but, occasionally, recourse to the courts by either party may be necessary to settle a dispute. Appeals from a design review committee judgment about a particular proposal may also be handled administratively by recourse to the Board of Directors of the HOA; this appeal is analogous to the appeal process to a city council in public design review programs.

Appendix II: Solar Installation Guidelines: Three Examples

Palo Alto, California
    Guidelines for Solar Installations in Palo Alto (July, 1978)
    Options for Using the Guidelines
Columbia, Maryland: Portions for Guidelines for Residential Solar Collectors in Columbia (August, 1977)
Armond Piacopo — Homeowner's Association Guidelines for the Aesthetic Installation of Solar Collectors (October, 1978, Gaithersburg, Maryland)
    Architecturally Related — Installation Guidelines Liability

Palo Alto, California:

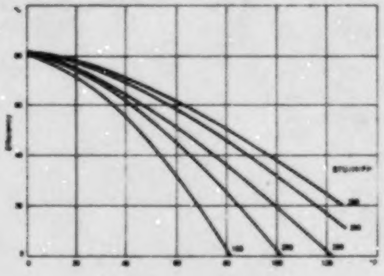
Guidelines For Solar Installations in Palo Alto (July, 1978)

The guidelines which follow are based on the discussion in Part I on visual problems with solar installations. When staff prepares the guidelines for public distribution, a very brief discussion of the rationale behind the guidelines will accompany them.

Placement of Collectors

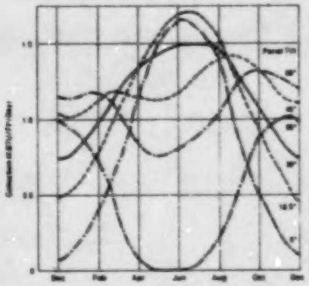
1. Panels laid flat on the roof are usually the most compatible with the form of the building.

   To be certain that you have sufficient collector area to do the heating job, calculate the area of collectors you need for your roof slope and roof orientation.



Efficiency Under Various Isolation Conditions

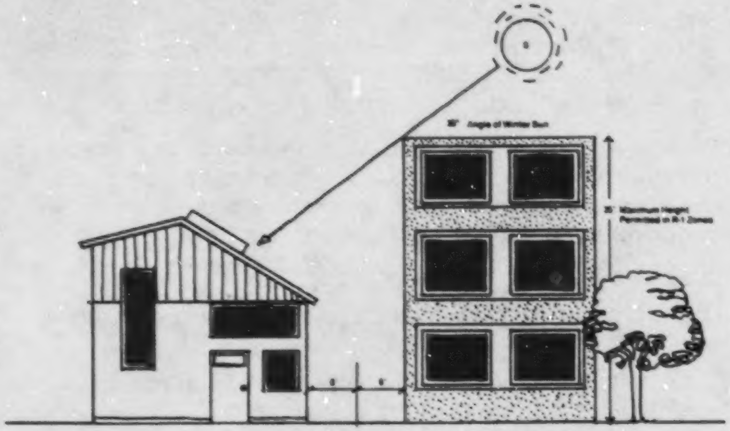
Most pool heating applications, even in the winter, are in a Δ T range between 20° and 30°F, which is easily handled.



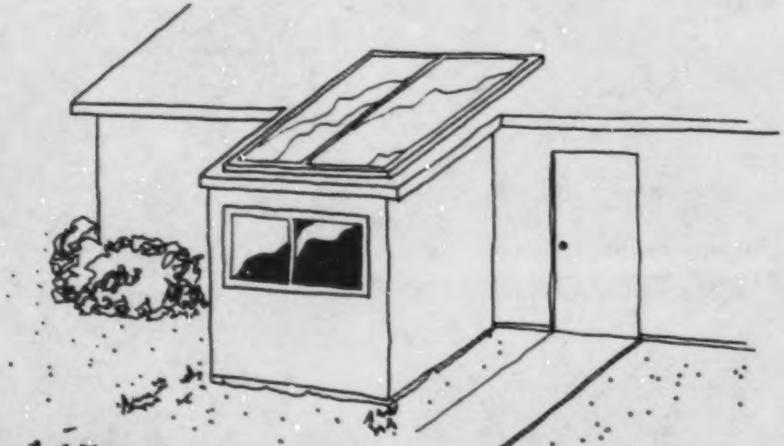
Solar Heat Collection at Different Tilt Angles

This graph shows the approximate amount of solar heat that will be collected daily for each square foot of collector area at different panel tilt angles. The diagram can be used for system sizing and tilt determination.

2. Locate the collector array so as to limit the need to remove or trim trees.
3. Locate the solar collectors so as to avoid light reflection into neighboring windows.
4. Locate the solar collectors so that future buildings on adjacent lots will not obstruct sunlight falling on your collectors.


Angle of Winter Sun
Maximum Height Permitted in R-1 Zones

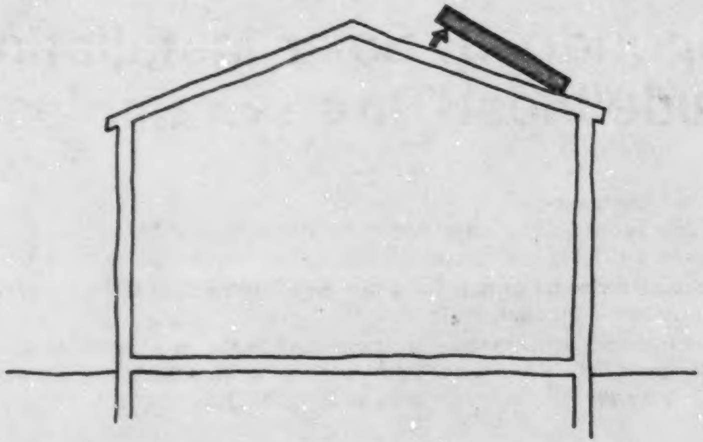
5. Locate the collector array so that it lies between the visually dominant lines of building and/or roof.



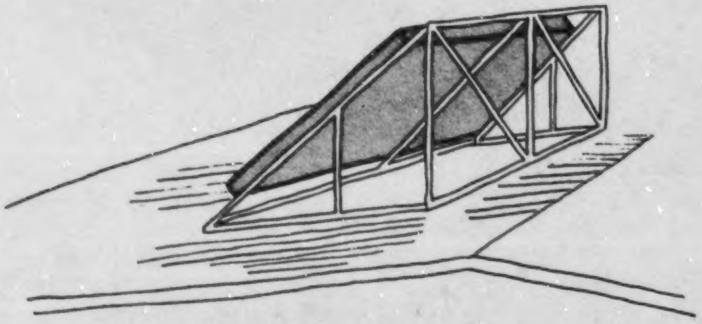
6. Where possible, locate collectors where they are least visible from a public street and other properties.

Panel Mounting:

7. If racks are used to mount the collectors, the smaller the angle between the roof surface and the collectors surface, the better the solar collector will blend with the roof.



8. A collector array placed over the ridge line will usually make the installation dominate the roof.
9. Thin steel rack mounts are usually incompatible with the roof volume. Covering the triangular ends with the roof or siding material usually makes the installation look better.



10. Installations that start at the ridge line and end at the gutter, usually look better.
11. Installations with spaces between collectors do not look as good as panels that fit snugly together.

    (Note: Some types of collectors require piping between panels.)
12. Minimize the amount of visible piping.

Color

13. When the color of the collector frame and the color of the roof match, the installation will be less visible.
14. The color of the piping should match the surface to which it is attached.

    (Note: Use nonreflective paint.)
15. Plastic bag collectors and plastic tubing are usually unattractive. To locate them where they are least visible or use a screening device to block the view of them.

Options for Using the Guidelines

Several options exist for using the guidelines effectively — from merely distributing them to interested persons to providing design review and consultation.

A survey of residents interested in installing solar systems indicated that 88% of them thought that homeowners would benefit from some architectural design review of solar installations at no charge. However, only 14% of the residents believed that the Architectural Review Board should have approval power over solar installations on single-family houses. (See Appendix II.) Based on the survey and the seriousness of the aesthetic problems as identified by ARB and staff, the following implementation procedure is proposed:

> The Inspectional Services Division will route all solar installations to the Planning Department. Planning staff will rate each proposed installation according to the rating system in the following table.
>
> For those installations exceeding 1.5 on the rating scale, Planning staff or the ARB will make design suggestions prior to issuance of building permits.

Staff anticipates approximately one-third of all applications to score over 1.5 points in the rating at first, and then to diminish rapidly as the guidelines become familiar to users. If the present demand for solar installations does not significantly increase, this can be handled by present Planning and Inspectional Services staff.

Solar Installation Rating System

Add total points on each item checked in the "yes" column. If total is over 1.5, Planning staff makes design suggestions prior to issuing building permits or suggests ARB review

	No	Yes	Rating
1. Do collectors reflect into neighboring windows?			1
2. Is installation visible from the street?			1
3. Will trees be removed or trimmed?			1
4. Is installation higher than ridge line?			.5
5. Does installation stand more than 3' above the roof surface?			.5
6. Is the color of collector frames compatible with the roof?			.5
7. Is the piping visible and does it blend with the surface it is attached to?			.5
8. Are the ends of the panel arrays not covered or are mounting brackets visible?			.5

Columbia, Maryland: Portions of Guidelines for Residential Solar Collectors in Columbia (August, 1977)

a. Architecturally collectors appear inappropriate on traditional homes since they are contemporary in character and consequently are discouraged. However, if required, a location on a side or rear facing roof slope or a free standing collector in the rear yard would be the most appropriate. Where the collector needs to be located on the front of a traditional house, it should be incorporated into the garage roof where it is likely to be less obtrusive than on the main roof. See page 8.

b. Large heating collectors usually providing the primary heating source for a house, and located on a sloping roof, should appear integral with the roof construction and not an appendage laying on top of it. Construction details at ridge, eaves and verge (or valley) are critical in achieving this appearance and should be comprehensively illustrated on construction plans. The use of a barge board of the same depth for all verges is imperative. See page 12. Primary collectors on flat roofs should be set back from the eaves and concealed from view by a parapet unless initially integrated as a visual feature of the architectural design of the house.

c. Small ancillary collectors generally used in supplementing the domestic hot water supply and not exceeding 60 sq. ft. ± may be laid on top of sloping roofs and project above the general roof surface to simulate the appearance of a skylight. Any collector larger than this should follow the guidelines in item a, since its size would make it a major visual feature of the house. See page 9.

d. Materials should be glass with wood or metal frames detailed to avoid ledges catching water. Plexiglass is not acceptable since it is liable to sag giving an unsatisfactory appearance.

e. Exposed pipe work will not be permitted.

f. All frames, flashings, etc. should be painted to match the adjacent roof surfaces in color or to match the house trim color, whichever is least obtrusive.

g. Approval of the Architectural Committee must be received prior to the construction of any solar collector whether attached to a house or free standing.

A solar collector for a new house should be included with the usual drawings submitted by the builder to the H.R.D. Architectural Committee for architectural approval.

The addition of a solar collector to an existing house should be submitted to the appropriate Village Community Association. Submission drawings should include a site plan plus elevations of the house showing the appearance of the collector and construction details showing how it is to be installed. For sloping roof installations submit also details illustrating the termination at roof ridge verge (or valley) and eaves.

Armond Piscopo, Homeowner's Association Guidelines for the Aesthetic Installation of Solar Collectors (October, 1978, Gaithersburg, Maryland).[1]

Architecturally Related — Installation Guidelines

Five items can be identified as major contributing factors in developing architectural compatibility between solar collectors and the home. These items relate to solar collector Style, Color, Arrangement, Mounting and Piping (SCAMP). Each of these items is discussed separately, but only to the extent that they affect the appearance of the installation.

1. Solar Collector Style

Most commercially available solar collectors designed for domestic hot water systems are acceptable.

Homemade, "improvised" collectors are generally not acceptable.

Solar collectors used to generate domestic hot water for the residential market are rectangular in shape and usually 2 to 3 feet wide, 6 to 9 feet long and from 4 to 6 inches deep. The glass surface of these collectors is flat, although at least one manufacturer offers a collector with a curved or arched surface.

2. Solar Collector Color

Only one color must be associated with the solar collector installation.

The color selected must blend harmoniously with the surface on which collectors are mounted. In the case of ground collectors the color selected must be compatible with the background against which the collectors will be viewed.

The frame of most commercially available solar collectors can be painted. Therefore, the solar collector frame along with any supporting structure and hardware must all adhere to the "single-color" criteria in order to minimize contrast.

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[1] Mary Freelins' illustrations for the *Guidelines* were the basis of the drawings in this volume, by Dava Lurie.

3. Arrangement of Solar Collectors

Solar collectors must be grouped together.

Perimeter lines of the collectors should be aligned or centered with other elements of the home's exterior, such as windows, doors and surface edges.

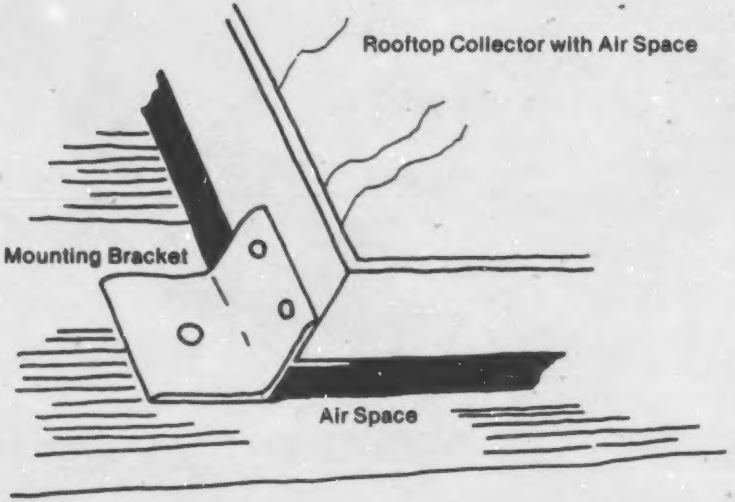
Visual appeal is influenced by many factors. Geometric balance, proportion and composition are a few examples of such factors and are unique to every installation. These factors should be reviewed thoroughly when considering the exact placement of the collectors on a roof or wall.

4. Mounting Solar Collectors

Solar collectors may be inlaid into the surface, mounted flat on the surface, or raised an inch or so parallel to the surface on which they are mounted.

"Racks", which provide collectors with slopes different from the surface on which they are mounted, must be enclosed. The enclosure must be architecturally compatible with the home in both material and color.

Ground collectors must also be rack-mounted with an enclosure which is architecturally compatible with the home in both material and color.


Rooftop Collector with Air Space

It has become widespread practice to mount roof collectors an inch or so above the roof as illustrated. This will allow rainwater or melting snow to pass under the collectors, and avoids the difficulty associated with caulking and the visual objections with metal flashing, normally associated with inlaid and flat-on-the-roof type mountings.

Wall collectors will almost always require a rack to establish the proper tilt angle. The design of a rack to support a wall collector is essentially the same as that for a roof collector.

Numerous designs are possible with ground collectors. The homeowner may choose to utilize the ground collector enclosure as a tool shed in the yard of the home. In some cases it may be possible to inlay solar collectors into the side of a small hill or berm on the property.

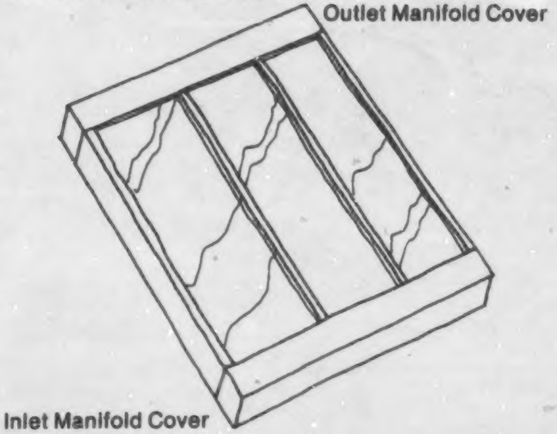
In all cases the color of the enclosure must adhere to the same single-color chosen for the entire installation. All mounting hardware such as bolts, screws, washers, mounting angles, and clips should be protected against corrosion and should consist of galvanized steel, aluminum or other noncorrosive metal.

5. Piping

All manifold piping must be enclosed.

Piping to-and-from manifolds should be routed through the interior of the home.

Rooftop Collectors with Manifold Covers



Inlet and outlet manifold pipes are generally routed external to the collectors and are wrapped with insulation. To avoid the appearance of these insulated pipes they are required to be enclosed with a cover. The covers may be an extended part of the solar collector frame, as illustrated.

It may become necessary to rack mount solar collectors to achieve the proper tilt angle. Such a decision should be based on the recommendation of a qualified solar industry representative. While the rack (i.e. the metal frame supporting the collectors illustrated in the accompanying figure) may be necessary to achieve the proper technical performance, it can detract from the architecture of the home. Therefore, all sides of a rack supporting any solar collector must be enclosed. The enclosure will give the collectors an appearance of continuity with the lines of the home. Two variations of rack mounted collectors with enclosures are illustrated. Innovative combinations of solar collector styles, arrangements and enclosures, are numerous. In each case the solar unit as a whole must be geometrically compatible with other architectural features of the home. The complete solar unit may be mounted flat on the roof or raised an inch or so to allow rain or melting snow to pass under the unit.

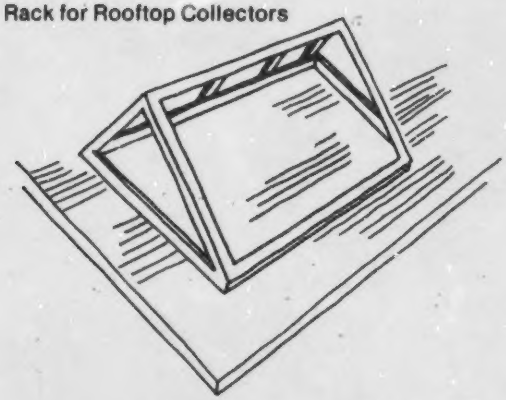
In the event that it becomes absolutely necessary to run inlet and outlet piping external to the home, it must be enclosed in a single conduit. Such a conduit must be square or rectangular in shape, made of wood and painted the same color as the surface on which it is mounted. Conduits must run parallel to the surface lines on which they are mounted and hidden under overhangs wherever possible. Inlet and outlet piping for ground collectors must be buried below ground level.

Only one pair purging mechanism may be visible and must not protrude more than 4 inches from the outlet manifold. Some insulation around the air purging mechanism may be visible.

Liability

1. The Association assumes no responsibility for the solar collector system, its performance or for structural damage, wind damage or glare resulting from the design, installation or use of the collector system.
2. These guidelines do not supercede local building, plumbing, electrical, fire and safety or health codes. It is the responsibility of the homeowner to acquire all necessary county permits in addition to architectural approval by the Association.
3. The Association assumes no responsibility in disputes involving rights of access to sunlight, either at the time of the installation or anytime in the future.

Rack for Rooftop Collectors



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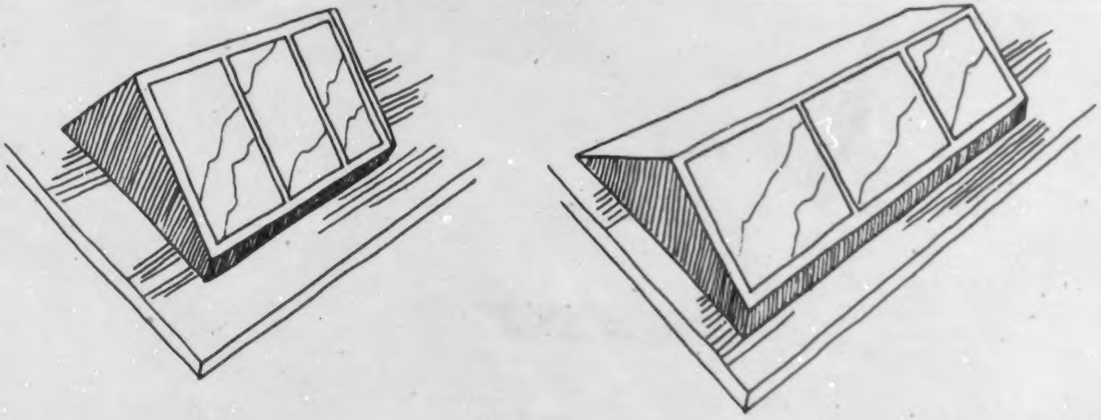
Rack-Mounted Rooftop Collectors with Enclosures



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Calculates sun angles and azimuths in the United States from 24° North latitude in 4° increments.

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An index of ornamental plants and their uses in the western portion of the United States. The book includes maps of the microclimates of the West and indicates which plants are best adapted to them. The maps can serve as valuable design tools making the book useful for landscape planning.

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A guide for developers, site planners, and builders in the design of residential developments for solar access. Includes general design approaches and specific design strategies.

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A guide for planning with vegetation and landforms. Includes sections on site selection and analysis and site planning for solar architecture. A number of case studies are given for various climatic regions.

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A British study of residential planning. Includes design standards for narrow streets and pedestrian walkways; covers a wide variety of key planning elements.

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This handbook is similar in format and content to Urban Planning and Design Criteria except that it concentrates on housing and subdivisions.

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